SPECIES ACCOUNT: *Alasmidonta atropurpurea* (Cumberland elktoe)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Cumberland elktoe is a freshwater mussel with a thin, but not fragile, shell. The outside surface of the shell (periostracum) is smooth, somewhat shiny, and covered with greenish rays. Young specimens have a yellowish brown periostracum, while specimens of adults are generally much darker. The inside surface of the shell (nacre) is shiny, with the color being white, bluish white, or sometimes peach or salmon.

Taxonomy

This species is quite similar to Alasmidonta marginata, but tends to differ from the latter by its darker color, less pronounced corrugations on the posterior slope, and the less acutely angular development of the posterior ridge. In older individuals of A. atropurpurea, the posterior ridge may be rather high and the resulting slope may be quite steep, but the posterior ridge retains a rounded character. The two species may occur in adjacent stream systems but do not appear to be sympatric at any locality.

Historical Range

The Cumberland elktoe is limited in distribution to the upper Cumberland River system in southeast Kentucky and north-central Tennessee, occupying streams both above and below Cumberland Falls. This species appears to have occurred only in the main stem of the Cumberland River and primarily its southern tributaries upstream from the hypothesized original location of Cumberland Falls near Burnside, Pulaski County, Kentucky (Cicerello and Laudermilk 2001). The original type locality was simply “river Cumberland,” according to Clarke (1981), who, upon ascertaining that the type specimen was lost, designated a neotype from the Clear Fork, a tributary to the Big South Fork, in Fentress County, Tennessee. All verified sites of occurrence are in the Cumberland Plateau Physiographic Province, giving it one of the most restricted ranges of any Cumberlandian species. There has been confusion about the historical distribution of this species because of its similarity to a congener--the elktoe (Cicerello and Laudermilk 2001). Museum and literature records of A. marginata from the Cumberland River drainage on the Cumberland Plateau should be verified, because they may actually represent the Cumberland elktoe. The Cumberland elktoe has apparently been extirpated from the main stems of the Cumberland and Laurel Rivers (and its tributary, Lynn Camp Creek). Considered a “rare species” by Clarke (1981), few sites are known to have ever harbored the Cumberland elktoe.

Current Range

The Cumberland elktoe is limited in distribution to the upper Cumberland River system in southeast Kentucky and north-central Tennessee, occupying streams both above and below Cumberland Falls. This species appears to have occurred only in the main stem of the Cumberland River and primarily its southern tributaries upstream from Cumberland Falls near Burnside, Pulaski County, Kentucky. All verified sites of occurence are in the Cumberland Plateau Physiographic Province, giving it one of the most restricted ranges of any Cumberlandian mussel species. Extant populations exist in 12 tributaries: Laurel Fork, Claiborne County, Tennessee and

Whitley County, Kentucky; Marsh Creek, McCreary County, Kentucky; Sinking Creek, Laurel County, Kentucky; Rock Creek, McCreary County, Kentucky; Big South Fork, Scott County, Tennessee, and McCreary County, Kentucky; North White Oak Creek, Fentress County, Tennessee; Clear Fork, Fentress, Morgan, and Scott Counties, Tennessee; North Prong Clear Fork, Fentress County, Tennessee; Crooked Creek, Fentress County, Tennessee; White Oak Creek, Scott County, Tennessee; Bone Camp Creek, Morgan County, Tennessee; and New River, Scott County, Tennessee.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 8/31/2004.

Legal Description

On August 31, 2004, the U.S. Fish and Wildlife Service (Service) designated 13 river and stream segments (units) in the Tennessee and/or Cumberland River Basins, encompassing a total of approximately 885 river kilometers (rkm) (550 river miles (rmi)) of river and stream channels, as critical habitat for the Cumberland elktoe (Alasmidonta atropurpurea) under the Endangered Species Act of 1973, as amended (69 FR 53136 - 53180).

Critical Habitat Designation

The critical habitat units include the stream and river channels within the ordinary high-water line. As defined in 33 CFR 329.11, the ordinary high water line on nontidal rivers is the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas. Critical habitat for the Cumberland elktoe (Alasmidonta atropurpurea) occurs in Units 8, 9, 11, 12, 13 in KY and TN.

Unit 8. Rock Creek, McCreary County, Kentucky. Unit 8 includes 17.4 rkm (11.0 rmi) of the main stem of Rock Creek and begins at the Rock Creek/White Oak Creek confluence and extends upstream to the low water crossing at rkm 25.6 (rmi 15.9) approximately 2.6 km (1.6 mi) southwest of Bell Farm in McCreary County, Kentucky. This unit, which is bounded by the DBNF and some private inholdings, is currently occupied by the Cumberland elktoe (Cicerello 1996).

Unit 9. Big South Fork and Tributaries, Fentress, Morgan, and Scott Counties, Tennessee, and McCreary County, Kentucky. Unit 9 encompasses 153 rkm (95 rmi) and consists of 43 rkm (27 rmi) of the Big South Fork of the Cumberland River main stem from its confluence with Laurel Crossing Branch downstream of Big Shoals, McCreary County, Kentucky, upstream to its confluence with the New River and Clear Fork, Scott County, Tennessee; 11 rkm (7 rmi) of North White Oak Creek from its confluence with the Big South Fork upstream to Panther Branch, Fentress County, Tennessee; 14.5 rkm (9.0 rmi) of the New River from its confluence with Clear Fork upstream to U.S. Highway 27, Scott County, Tennessee; 40 rkm (25 rmi) of Clear Fork from its confluence with the New River upstream to its confluence with North Prong Clear Fork, Morgan and Fentress Counties, Tennessee; 10 rkm (6 rmi) of White Oak Creek from its confluence with Clear Fork upstream to its confluence with Bone Camp Creek, Morgan County, Tennessee; 6 rkm (4 rmi) of Bone Camp Creek from its confluence with White Oak Creek upstream to Massengale Branch, Morgan County, Tennessee; 14.5 rkm (9.0 rmi) of Crooked Creek from its confluence with Clear Fork upstream to Buttermilk Branch, Fentress County, Tennessee; and 14.5 rkm (9 rmi) of North Prong Clear Fork from its confluence with Clear Fork upstream to Shoal Creek, Fentress County, Tennessee. The main stem of the Big South Fork currently supports the Cumberland elktoe and the best remaining Cumberlandian combshell population in the Cumberland River System (Bakaletz 1991; Gordon 1991; R.R. Cicerello, pers. comm. 2003). The main stem of the Big South Fork historically contained the oyster mussel (S.A. Ahlstedt, pers. comm. 2002; Service 2004). The Epioblasma mussel that currently inhabits the Big South Fork main stem, and that is occasionally referred to as the oyster mussel, is now recognized as a sister species of the tan riffleshell (see ‘‘Taxonomy, Life History, and Distribution’’ section) (Service 2004; J. Jones, pers. comm. 2003). The remainder of the unit contains habitat currently occupied by the Cumberland elktoe (Call and Parmalee 1981; Bakaletz 1991; Gordon 1991). The largest population of Cumberland elktoe in Tennessee is in the headwaters of the Clear Fork System (Call and Parmalee 1981; Bakaletz 1991). The Big South Fork and its many tributaries may actually serve as habitat for one large interbreeding population of the Cumberland elktoe (Service 2004).

Unit 11. Sinking Creek, Laurel County, Kentucky. Unit 11 encompasses 13 rkm (8 rmi) and extends from the Sinking Creek/ Rockcastle River confluence upstream to Sinking Creek’s confluence with Laurel Branch in Laurel County, Kentucky. The Cumberland elktoe is present but uncommon in this Unit (R.R. Cicerello, pers. comm. 2003). This unit is primarily within land owned by the DBNF, but also includes private lands.

Unit 12. Marsh Creek, McCreary County, Kentucky. Unit 12 includes 24 rkm (15 rmi) and consists of Marsh Creek from its confluence with the Cumberland River upstream to the State Road 92 Bridge in McCreary County, Kentucky. This unit, which is bounded by lands owned by the DBNF and private landowners, currently contains the State of Kentucky’s best population of Cumberland elktoe (R.R. Cicerello, pers. comm. 2003) and the best remaining mussel fauna in the Cumberland River above Cumberland Falls (Cicerello and Laudermilk 2001).

Unit 13. Laurel Fork, Claiborne County, Tennessee, and Whitley County, Kentucky. Unit 13 includes 8 rkm (5 rmi) of Laurel Fork of the Cumberland River from the Campbell/Claiborne County line upstream 11.0 rkm (6.9 rmi) through Claiborne County, Tennessee, to Whitley County, Kentucky. The upstream terminus is 3 rkm (2 rmi) upstream of the Kentucky/Tennessee State line. A ‘‘sporadic’’ population of Cumberland elktoe currently persists in this area (Cicerello and Laudermilk 2001).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the purple bean (Villosa perpurpurea) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the five mussels and their host fish;

(ii) Geomorphically stable stream and river channels and banks;

(iii) Stable substrates consisting of mud, sand, gravel, and/or cobble/ boulder, with low amounts of fine sediments or attached filamentous algae;

(iv) Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and

(v) Fish hosts with adequate living, foraging, and spawning areas for them.

Special Management Considerations or Protections

All 13 critical habitat units identified in the final designation may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, or presence of fish hosts. All of these units are threatened by actions that alter the stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); and point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation. Habitat fragmentation, population isolation, and small population size compounds these threats to the species. Various activities in or adjacent to each of the critical habitat units described in the final rule may affect one or more of the primary constituent elements that are found in the unit.

The critical habitat does not include existing features of the human-built environment such as water intakes and outfalls, low-level dams, bridge footings, piers and abutments, boat ramps, and exposed pipelines. As such, Federal actions limited to these areas would not trigger consultation pursuant to section 7 of the Act, unless they affect the species or destroy or adversely modify its critical habitat.

Life History

Feeding Narrative

Larvae: Glochidia rely on a host (northern hogsucker (Hypentelium nigricans), banded sculpin (Cottus carolinae), redline darter (Etheostoma rufilineatum), and fantail darter (Etheostoma flabellare))

Juvenile: Juvenile mussels employ foot (pedal) feeding and are thus suspension/deposit feeders (Yeager et al. 1994). The juvenile diet (up to 2 weeks of age) includes bacteria, algae (i.e., nonfilamentous, non-blue green), and diatoms, with some detrital and inorganic colloidal particles (Yeager et al. 1994).

Adult: Adult freshwater mussels are filter feeders, orienting themselves in the substrate to facilitate the siphoning of the water column for oxygen and food (Kraemer 1979). Specific food habits of the oyster mussel is unknown, but they likely ingest food items similar to those consumed by other riverine mussels. Mussels are known to consume bacteria, detritus, assimilated organic material, diatoms, phytoplankton, zooplankton, phagotrophic protozoans, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Ukeles 1971, Fuller 1974, Baldwin and Newell 1991, Neves et al. 1996).

Reproduction Narrative

Adult: Freshwater mussels generally have separate sexes, although hermaphroditism is known for some species (van der Schalie 1970, Bauer 1987, Downing et al. 1989). The age of sexual maturity for mussels is variable, usually requiring from 3 years to about 10 years, when complete maturity is reached (Zale and Neves 1982; Haag and Staton, in press), and may be sex dependent (Smith 1979). Males expel clouds of sperm into the water column, although some species expel spermatozeugmata (sperm balls), which consist of thousands of sperm (Barnhart and Roberts 1997). Females draw in sperm with the incurrent water flow. Fertilization takes place in their suprabranchial chambers, and the resulting zygotes develop into specialized veliger larvae, termed “glochidia,” in the water tubes of the gills. Spawning appears to be dependent on the temperature (i.e., spawning is initiated when the water temperature reaches a certain point; Zale and Neves 1982, vBruenderman and Neves 1993) but may also be influenced by stream discharge (Hove and Neves 1994). Fertilization rates are dependent on the spatial aggregation ofreproductive adults (Downing et al. 1993). Mussels are generally categorized as either short-term summer brooders (tachytictic) or long-term winter brooders (bradytictic) (Neves and Widlak 1988). Tachytictic species have a spring fertilization period; the glochidia are then incubated for a few months and are expelled during the summer or early fall. Bradytictic species have a late summer or early fall fertilization period, with the glochidia incubating over the winter, and are expelled the following spring or early summer. Glochidia may number in the tens of thousands to several million (Surber 1912, Coker et al. 1921, Yeager and Neves 1986). Mussel fecundity is thought to be positively related to body size and inversely related to glochidia size (Bauer 1994). Haag and Staton (in press) determined that fecundity was best related to shell length, but also to age. However very large or old individuals tend to exhibit a decline in fecundity. Extant populations of mussels tend to be skewed toward larger adults, strongly indicating that survival rates to the adult stage must be very low. After a variable incubation period, glochidia are expelled into the water column. Glochidia must come into contact with specific species of fish whose gills and fins they temporarily parasitize. Glochidia are generally released individually in netlike mucoid strands that entangles fishes (Haag and Warren 1997) or as discreet packets, termed “conglutinates,” which represent all the glochidial contents (and sometimes eggs) of a single water tube packaged in a mucilaginous capsule (Ortmann 1910, 1911). Conglutinates often resemble colorful fish prey items (e.g., worms, insect larvae, fish fry) (Chamberlain 1934, Luo 1993, Hartfield and Hartfield 1996), and researchers havedemonstrated that conglutinates are actively foraged by fish (Ortmann 1911; Neves and Widlak 1988; Weiss and Layzer 1995; Haag and Warren 1997, 2003a; Layzer et al. 2003). Mantle displays have been shown to actively elicit attacks from fish (Haag and Warren 1999), and mantle lures potentially reduce the chances that glochidia will infest an unsuitable fish host (Haag et al. 1999). Host specificity appears to be common in mussels (Neves 1993), with most species utilizing only a few host fishes (Lefevre and Curtis 1912; Zale and Neves 1982; Yeager and Saylor 1995; Haag and Warren 1997, 2003a). The parasitic stage generally lasts a few weeks (Neves et al. 1985, O’Brien and Williams 2002), but can last up to six weeks or so (Yeager and Saylor 1995, Haag and Warren 1997, Zimmerman and Neves 2002), and is dependent on temperature and the species (Watters and O’Dee 2000, Zimmerman and Neves 2002). After dropping from fish hosts, newly metamorphosed juveniles passively drift with currents and ultimately settle in depositional areas with other suspended solids (Neves and Widlak 1987, Yeager et al. 1994). Juveniles must, however, come into contact with suitable habitat to begin their free-living existence (Howard 1922). Survival rates for a glochidium to metamorphosis ranges from 0.000001 (Young and Williams 1984) to 0.0001 (Jansen and Hanson 1991) percent, not factoring in predation after metamorphosis (Watters and Dunn 1993-94). The rates of recruitment needed to maintain viable mussel populations are not known. Glochidial parasitism serves as a means of dispersal for this relatively sedentary group (Neves 1993). The Cumberland elktoe was found gravid from October through May, but no fish have been observed infested with its glochidia until March. Cumberland elktoe glochidia to develop equally well on both fin and gill surfaces. Five native fish species were parasitized by Cumberland elktoe glochidia--whitetail shiner (Cyprinella galactura), northern hogsucker (Hypentelium nigricans), rock bass (Ambloplites rupestris), longear sunfish (Lepomis megalotis), and rainbow darter (Etheostoma caeruleum). However, under laboratory conditions, juvenile specimens transformed only on the northern hogsucker (Gordon and Layzer 1993). The period of glochidial encystment (i.e., until transformation into free-living juveniles) took 24 days, at 66.2° ± 5.4°F.

Geographic or Habitat Restraints or Barriers

Larvae: dams

Juvenile: dams

Adult: dams

Spatial Arrangements of the Population

Larvae: clumped according to suitable resources

Juvenile: clumped according to suitable resources

Adult: clumped according to suitable resources

Environmental Specificity

Larvae: Specific host requirements

Juvenile: Moderate. Generalist or community with some key requirements scarce.

Adult: Moderate. Generalist or community with some key requirements scarce.

Site Fidelity

Larvae: depends on host

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: depends on host

Juvenile: Not applicable

Adult: Not applicable

Habitat Narrative

Adult: Adult mussels are ideally found in localized patches (beds) in streams, almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Vannote and Minshall 1982, Neves and Widlak 1987, Leff et al. 1990, Strayer 1997). Physical qualities of the sediment (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediment, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999). Water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams (Huehner 1987). The Cumberland elktoe inhabits medium-sized rivers and may extend into headwater streams where it is often the only mussel present (Gordon and Layzer 1989, Gordon 1991). Gordon and Layzer (1989) reported that the species appears to be most abundant in flats, which were described by Gordon (1991) as shallow pool areas lacking the bottom contour development of typical pools, with sand and scattered cobble/boulder material, relatively shallow depths, and slow (almost imperceptible) currents. They also report the species from swifter currents and in areas with mud, sand, and gravel substrates.

Dispersal/Migration

Motility/Mobility

Larvae: Moves with host

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Dependent on host

Juvenile: Non-migratory

Adult: Non-migratory

Dispersal

Larvae: dependent on host

Juvenile: Limited; passive movement via flushing event

Adult: Limited; passive movement via flushing event

Dependency on Other Individuals or Species for Dispersal

Larvae: yes; host

Dispersal/Migration Narrative

Larvae: Primary dispersal of the Cumberland Elktoe is likely via through host.

Juvenile: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Adult: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
unknown

Number of Populations:
6 (USFWS, 2022)

Population Size:
2500 to 10,000 individuals

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Considered a “rare species” by Clarke (1981), few sites are known to have ever harbored the Cumberland elktoe. Marsh Creek harbors the largest population known in Kentucky (Cicerello 1995), and the population in Rock Creek is also sizable (Cicerello 1996). In both streams the Cumberland elktoe represented the second most abundant unionid species (Cicerello 1995, 1996). The Marsh Creek population, with at least three year classes present, is viable, but the viability of the Rock Creek population is questionable (R. R. Cicerello, Kentucky State Nature Preserves Commission, pers. comm., 2000). The population in Laurel Fork is small, difficult to find, and of questionable viability. Though larger, the status of the Sinking Creek population is unknown (Cicerello, pers. comm., 2003). The largest populations in Tennessee are in the Big South Fork system in the headwaters of the Clear Fork system, where several hundred specimens were found in muskrat middens in the late 1980s (Bakaletz 1991; Layzer, pers. comm., 1998). Several age classes of the Cumberland elktoe were represented in samples taken from throughout the larger tributaries of the Big South Fork system metapopulation in Tennessee during a 1985-86 survey (Bakaletz 1991). Based on sampling conducted in 2002, the populations in White Oak and North White Oak Creeks are among the largest viable populations

rangewide (Ahlstedt, pers. comm., 2003). The Cumberland elktoe historically had a rather limited distribution. Its distribution has been further restricted by pollution from coal mine run-off and other sources, and by impoundments. The continuing development of coal mines, particularly strip mines, poses the primary threat to the limited habitat. This species has a limited range in one river system in the Cumberland Plateau in Tennessee and Kentucky that is fragmented into three disjunct sections of the former range and has experienced decline (50-70%) over the years to about a dozen occurrences, only two or three of which are considered to have decent viability. Area of occupancy within the narrow range is discontinuous and very small and continued decline has been observed recently. In April 2014, Ahlstedt (2014, pers. comm.) found 12 live Cumberland elktoe at Bone Camp Creek and 1 live at North White Oak Creek, both sites in Morgan County, Tennessee. In September 2014, Dinkins (2014) found 2 Cumberland elktoe downstream of the Zenith Crossing on North White Oak Creek. In April 2013, 15 gravid females were observed in Clear Fork in the Big South Fork Cumberland River (McGregor 2013, unpubl. report). In 2011 qualitative and quantitative samples at the same site (Peter's Bridge – Clear Fork), Cumberland elktoe was the most abundant species (McGregor 2012). Forty-seven individuals were found measuring from 34-124 mm in length and from 2 to 15 years of age (McGregor 2012, pers. comm.). In 2007, 5 live individuals were found in soft substrates in Buffalo Creek, a tributary to the New River (Ahlstedt et al. 2008). Coal fines were observed at the site, and mussels were found at the head of a shoal. In 1988, Layzer and Moles (2009) estimated the population size of Cumberland elktoe in North Prong Clear Fork (2.33/square meter) and Bone Camp Creek (0.52/square meter). In 2008, only one live mussel was found at North Prong Clear Fork and no live mussels were found in the same Bone Camp Creek site (Layzer and Moles 2009). The authors hypothesized that Cumberland elktoe continue to persist because they have adapted to the unpredictable nature of life in headwater streams (i.e., variablility of flows and predation) (USFWS, 2015).

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The decline, extirpation, and extinction of mussel species is overwhelmingly attributed to habitat alteration and destruction (Neves 1993), primarily manifest in the conversion of riverine systems to impoundments (Yeager 1993 1994). Impoundments, especially large main-stem reservoirs, have significantly altered riverine ecosystems (Baxter and Glaude 1980, Williams et al. 1992, Allan and Flecker 1993, Ligon et al. 1995, Sparks 1995) and have been a major factor in the high extinction rate oof freshwater mollusks (Johnson 1978, Lydeard and Mayden 1995, Neves et al. 1997). Impoundments result in the elimination of riffle and shoal habitats and the subsequent loss of mussel resources (Ortmann 1925; van der Schalie 1938; Scruggs 1960; Bates 1962; Neel 1963; Isom 1969, 1971; Stansbery 1970, 1973b; Fuller 1974; Schmidt et al. 1989; Williams et al. 1992; Layzer et al. 1993; Parmalee and Hughes 1993; Lydeard and Mayden 1995; Sickel and Chandler 1996; Watters 1996). Most of a river's ecological processes are also disrupted, for example, by modifying flood pulses; controlling impounded water elevations; increasing depth; decreasing habitat heterogeneity; altering water flow, sediment, nutrients, energy input and output, and the riverine biota; and causing the loss of bottom stability due to subsequent sedimentation (Williams et al. 1992, Ligon et al. 1995, Sparks 1995, Watters 2000). The elimination of current and the covering of rocky and sand substrates by fine sediments alters

the habitat of riverine species (including these five, typically shoal-inhabiting, species) to the point where they can no longer reproduce, recruit, and survive under impoundment conditions (Fuller 1974, Neves et al. 1997, Hughes and Parmalee 1999). In addition, dams can seriously alter downstream water quality and riverine habitat (Allan and Flecker 1993, Ligon et al. 1995, Collier et al. 1996) and negatively impact mussel populations in tailwaters (Cahn 1936b, Hickman 1937, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999, McMurray et al. 1999b, Vaughn and Taylor 1999). These changes include thermal alterations (Neves 1993), channel characteristics, habitat availability, and flow regimes that have drastic effects on the stream biota (Krenkel et al. 1979, Allan and Flecker 1993). Altered effects also include fish community shifts (Brim 1991) and the resultant colonization by fewer native species and more alien species (Williams and Neves 1992). Daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, cold-water releases, turbulence, high silt loads, and altered host fish distribution have contributed to limited mussel recruitment and skewed demographics (Sickel 1982, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, McMurray et al. 1999b). Cold-water releases from large nonnavigational dams are the result of placing water intake structures low on the dam to increase hydropower efficiency (Krenkel et al. 1979). The release of cold water and scouring of the riverbed from highly fluctuating, turbulent flows in tailwaters have also been implicated in the demise of Cumberlandian Region mussel faunas (Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999). Specifically, tachytictic species, which depend on warm summer temperatures to initiate gametogenesis, spawning, glochidia release, and the proper host fish being present, experience reproductive failure below dams (Heinricher and Layzer 1999). Bradytictic species are also negatively affected, and the decline of mussel populations has been manifested over a period of several decades (Neves 1999a). The mussel faunas of the middle Cumberland, lower Obey, lower Caney Fork, Little Tennessee, and Elk Rivers have been profoundly impacted by cold-water releases, including populations of the Cumberlandian combshell and oyster mussel. A reduction in water temperature, rapid changes in flow releases during hydropower peaking events, and the resultant bank sloughing and channel scouring have altered habitats so profoundly below hydroelectric dams that riverine species, including these five mussels, are unable to reproduce, recruit, and survive such conditions. The entire length of the main stems of the Tennessee and Cumberland Rivers and many of their largest tributaries are now impounded or greatly modified by the discharge of tailwaters. More than 2,300 river miles (about 20 percent) of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater were impounded by the TVA by 1971 (TVA 1971). The subsequent completion of additional major impoundments on tributary streams (e.g., Duck River in 1976, Little Tennessee River in 1979) significantly increased the total miles impounded behind the 36 major dams in the Tennessee Riversystem (Neves et al. 1997). Approximately 90 percent of the 562-mile length of the Cumberland River downstream of Cumberland Falls is either impounded (three locks anddams and the Wolf Creek Dam) or otherwise adversely impacted by cold-water discharges from the Wolf Creek Dam. Miller et al. (1984) located only two mussel specimens in a survey below the Wolf Creek Dam, which covered 68 miles of river that formerly harbored 39 species (Neel and Allen 1964). Other major U.S. Army Corps of Engineers (COE) impoundments on Cumberland River tributaries (e.g., Laurel River, Obey River, Caney Fork, Stones River) have inundated more than 125 miles of potential riverine habitat for the Cumberland elktoe, oyster mussel, and Cumberlandian combshell. Impoundments, as barriers to dispersal, contribute to the loss of local populations by blocking postextirpation recolonization (Luttrell et al. 1999). Population losses due to impoundments have probably contributed more to the decline of the Cumberlandian combshell, oyster mussel, and rough rabbitsfoot and most other Cumberlandian Region mussels than any other single factor (as the Cumberland elktoe and purple bean generally inhabit smaller rivers, impoundments have had less of an impact on them). Stream populations of these species thought to have been lost primarily or exclusively due to impoundments include the Cumberland River, Laurel River, Lynn Camp Creek, Rockcastle River, Beaver Creek, Obey River, Caney Fork, and Stones River in the Cumberland River system; and the South Fork Holston River, Holston River, Tennessee River, Little Tennessee River, Hiwassee River, Limestone Creek, Elk River, and Shoal Creek in the Tennessee River system. Reaches in other streams with extant populations of some of these species have also been destroyed by impoundments that invariably eliminated expanses of their occupied habitat (e.g., lower Big South Fork in the Cumberland River system; lower French Broad River, lower Little River [Tennessee], lower Clinch River, lower Powell River, lower Emory River, upper and lower Bear Creek, middle Duck River in the Tennessee River system). The majority of the extant populations of these species have been isolated due to impoundments (see “Patterns of Imperilment,” “Narrative Outline,” and Recovery Task 1.4.6 for a discussion of the consequences of population fragmentation), and some continue to decline and die off.

Stressor: Dredging and channelization
Exposure:
Response:
Consequence:
Narrative: Dredging and channelization activities have profoundly altered riverine habitats nationwide, with effects on streams summarized by Simons (1981), Bhowmik (1989), and Hubbard et al. (1993). DeHaan (1998) provided an annotated bibliography of sediment transport and deposition in large rivers. Hartfield (1993) and Neves et al. (1997) reviewed the specific effects of channelization on freshwater mollusks. Channelization impacts a stream’s physical (e.g., accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, riparian canopy loss) and biological (e.g., decreased fish and mussel diversity, changed species composition and abundance, decreased biomass and growth rates) characteristics (Stansbery and Stein 1971, Hartfield 1993, Hubbard et al. 1993). Since mussels need stable substrates to survive (Strayer 1999a), channel instability is probably the single most detrimental aspect of channelization (Hartfield 1993). Channel construction for navigation has been shown to increase flood heights (Belt 1975), thus exacerbating flood events that convey to streams large quantities of sediment with adsorbed contaminants. Channel maintenance may also result in downstream impacts (Stansbery 1970), such as increases in turbidity and sedimentation, which may smother benthic organisms. Impacts associated with barge traffic--the construction of fleeting areas, mooring cells, docking facilities, and propeller wash--also disrupt habitat. Although the volume of literature demonstrating the on-site and off-site environmental and economic consequences of dredging for navigation and flood control is substantial (Smith and Patrick 1991, Watters 2000), these activities continue in the Southeast. The entire length of the Tennessee River and much of the Cumberland River is maintained as a navigation channel with a series of locks and dams--nine on the Tennessee River and four on the Cumberland River. Although the dams themselves probably contributed more to the destruction of riverine habitat for mussels (including theoyster mussel and Cumberlandian combshell), channel maintenance activities continue to cause substrate instability and alteration in these rivers and may serve to diminish what habitat remains for the recovery of riverine species. Other streams, notably the lower Paint Rock River (Ahlstedt 1995-96) and portions of the Bear Creek system (McGregor and Garner, in press), have been channelized, primarily during ill-fated attempts to reduce flooding.

Stressor: Mineral extraction

Exposure:
Response:
Consequence:
Narrative: Heavy metal-rich drainage from coal mining and associated sedimentation have adversely impacted many stream reaches (Barnhisel and Massey 1969, Ahmad 1973, Curry and Fowler 1978), destroying mussel beds and preventing natural recolonization (Simmons and Reed 1973, McCann and Neves 1992). Neves et al. (1997) reviewed the effects of various mining activities on freshwater mollusks. The low pH commonly associated with mine runoff can lead to an inability of glochidia to clamp their valves on host tissues, thus preventing proper encystment (Huebner and Pynnönen 1992). Therefore, acid mine runoff may be having local impacts on the recruitment of, particularly, the Cumberland elktoe, since most of its range is within watersheds where coal mining is still occurring. In addition, interstitial spaces in streams, which is habitat critical for juvenile mussels, are clogged by sediment runoff from mines (Branson and Batch 1972). Circumstantial evidence indicates that salinity, a by-product of oil exploration activities, is lethal to some glochidia (Liquori and Insler 1985). Increased sedimentation and turbidity (see“Sedimentation,” in this section, for its effects on mussels), reduction in pH from chemicals associated with acid mine drainage, and heavy metals (see “Contaminants,” in this section, for their effects on mussels) have altered habitat in many streams to the point where mussels, including these species, are unable to reproduce, recruit, and survive these conditions. Impacts associated with coal mining activities have particularly altered upper Cumberland River system streams with diverse historical mussel faunas (Stansbery 1969, Blankenship 1971, Blankenship and Crockett 1972, Starnes and Starnes 1980, Schuster et al. 1989, Anderson et al. 1991) and have been implicated in the decline of Epioblasma species, especially in the Big South Fork (Neel and Allen 1964). Strip mining continues to threaten mussels in coal field drainages of the Cumberland Plateau (Anderson 1989, Warren et al. 1999) with increased sedimentation loads and acid mine drainage, including Cumberland elktoe and Cumberlandian combshell populations. The Marsh Creek population of the Cumberland elktoe has also been adversely affected and is still threatened by potential spills from oil exploration activities. Coal mining activities also occur in portions of the upper Powell and Clinch River systems, primarily in Virginia. Scores of active and inactive mines are known from these drainages (Hampson et al. 2000). Five mine tailings pond spills were reported from 1995 to 1999 in the upper Clinch and Powell River systems (Hampson et al. 2000), at least one of which resulted in a major fish kill (Koch, pers. comm., 1996). Research by Kitchel et al. (1981) indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981). Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. Known to be toxic to mussels and fishes, PAHs have been found at relatively high levels in the upper portions of the Clinch and Powell Rivers in Virginia (Hampson et al. 2000). In fact, Hampson et al. (2000) detected 29 different PAHs in stream sediment samples in the two watersheds. The Clinch River at Pendleton Island had concentrations of two measured PAHs, naphthalene and phenanthrene, at 400 micrograms per kilogram (µg/kg) and 570 µg/kg, respectively, both of which are above the protection guidelines for aquatic life. The Canadian probable-effect levels of 391 µg/kg and 515 µg/kg, respectively, have been established for these compounds. The probable-effect levels define concentrations above which adverse effects to aquatic organisms can be expected. Pendleton Island was once a stronghold for the rough rabbitsfoot and home to the oyster mussel, Cumberlandian combshell, and purple bean as well in the early 1980s (Ahlstedt 1991a). However, the fauna there was in marked decline less than a decade later. No live oyster mussels or Cumberlandian combshells were found in 1987 (Dennis

1989). Three other sites in the Clinch River system (i.e., lower Clinch River, Guest River, Copper Creek) had concentrations of these two compounds below the probable-effect levels. A site on the Powell River near Arthur, Tennessee, had much higher levels of naphthalene and phenanthrene (1,600 µg/kg and 1,300 µg/kg, respectively) than at Pendleton Island. In the Emory River, downstream of a population of the purple bean in the Obed River, excessive naphthalene levels were detected (610 µg/kg). In a quantitative study in the Powell River, Ahlstedt and Tuberville (1997) attributed a 15-year decline of the oyster mussel, Cumberlandian combshell, and rough rabbitsfoot and the long-term decrease in species diversity (from 30 in 1979 to 21 in 1994) to general stream degradation due primarily to coal mining activities in the headwaters. Mining activities also likely contributed to the extirpation of the purple bean from the Powell River several decades ago. Iron and phosphate mining in the Duck River watershed was thought to have caused mussel declines in the early 1900s (Ortmann 1924a).

Stressor: Gravel mining
Exposure:
Response:
Consequence:
Narrative: In-stream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, Yokley and Gooch 1976, Grace and Buchanan 1981, Hartfield and Ebert 1986, Schuster et al. 1989, Hartfield 1993, Howard 1997). Lagasse et al. (1980), Kanehl and Lyons (1992), and Roell (1999) reviewed the physical and biological effects of mining sediment from streams. Negative impacts include riparian forest clearing (e.g., mine site establishment, access roads, lowered floodplain water table); stream channel modifications (e.g., geomorphic instability, altered habitat, disrupted flow patterns [including lowered elevation of stream flow], sediment transport); water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature); macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation); and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions) (see discussion in “Sedimentation”). Once mussels have been eliminated, a decade or more may pass before recolonization occurs (Stansbery 1970, Grace and Buchanan 1981). Substrate disturbance and sedimentation impacts can also be realized for considerable distances downstream (Stansbery 1970), and possibly upstream (Hartfield 1993). Gravel mining activities threaten the Cumberlandian combshell populations in the Powell River and in Buck Creek, the latter stream representing one of only two remainingpopulations of this species in the entire Cumberland River system. Mining activities on the Elk River (Ahlstedt 1991b) may have played a role in the extirpation of the oystermussel and Cumberlandian combshell from that river. Gravel removal was apparent at 12 sites along a 40-mile stretch of the lower Elk River during 1999 mussel sampling(Anonymous 1999). Activities that occur without a permit, unless controlled, may prevent the long-term reintroduction of some of the 13 federally listed mussels that areknown from the Elk.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Contaminants contained in point and nonpoint discharges can degrade water and substrate quality and adversely impact, if not destroy, mussel populations (Horne and McIntosh 1979, Neves and Zale 1982, McCann and Neves 1992, Havlik and Marking 1987). Although chemical spills and other point sources (e.g., ditch, swale, artificial channel, drainage pipe) of

contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result, in part, from the subtle, pervasive effects of chronic low-level contamination (Naimo 1995). The effects of excessive concentrations of heavy metals and other contaminants on freshwater mussels were studied by Mellinger (1972), Fuller (1974), Havlik and Marking (1987), Naimo (1995), Keller and Lydy (1997), and Neves et al. (1997). Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also negatively affect biological processes (Jacobson et al. 1993, Naimo 1995, Keller and Zam 1991, Keller and Lydy 1997). In laboratory experiments, mussels suffered mortality when exposed to 2.0 parts per million (ppm) cadmium, 12.4 ppm chromium, 19.0 ppm copper, and 66.0 ppm zinc (Mellinger 1972, Havlik and Marking 1987). Most metals are persistent in the environment (Miettinen 1977), remaining available for uptake, transportation, and transformation by organisms for long periods (Hoover 1978). Highly acidic pollutants such as metals are capable of contributing to mortality by dissolving mussel shells (Stansbery 1995). Among other pollutants, ammonia has been shown to be lethal to mussels at concentrations of 5.0 ppm (Havlik and Marking 1987). Ammonia is oftentimes associated with animal feedlots, nitrogenous fertilizers, and the effluents of older municipal wastewater treatment plants (Goudreau et al. 1993). This contaminant may become more problematic for juvenile mussels during periods of low flow, when water temperatures increase (Newton et al. 2003b). In stream systems, ammonia is most prevalent at the substrate/water interface (Frazier et al. 1996). Due to its high level of toxicity and the fact that the highest concentrations occur in the microhabitat, where mussels live, ammonia should be considered among the factors potentially limiting the survival and recovery of mussels at some locations (Augspurger et al., in press). Certain adult species may tolerate short-term exposure (Keller 1993). However, the effects of heavy metals and other toxicants are especially profound on juvenile mussels (Robison et al. 1996) and on the glochidia, which appear to be very sensitive to toxicants such as ammonia (Goudreau et al. 1993). Low levels of some metals may inhibit glochidial attachment (Huebner and Pynnönen 1992). Juvenile mussels may inadvertently ingest contaminated silt particles while feeding (see “Food Habits”).Mussel recruitment may therefore be reduced in habitats with low but chronic heavy metal and other toxicant inputs (Yeager et al. 1994, Naimo 1995, Ahlstedt and Tuberville 1997), which may have contributed to the demise of these five species. Common contaminants associated with households and urban areas, particularly thosefrom industrial and municipal effluents, may include heavy metals, ammonia, chlorine, phosphorus, and numerous organic compounds. Nonpoint-source runoff from urbanareas tends to have the highest levels of many pollutants, such as phosphorus and ammonia, when compared to other catchments (Mueller et al. 1995). Wastewater is discharged at sites throughout the country with permits (and some without permits) issued by the National Pollution Discharge Elimination System (NPDES).Elimination sites are ubiquitous in watersheds containing rough rabbitsfoot populations, providing ample opportunities for some pollutants to enter streams. Collectively,pollutants from these sources may cause decreased dissolved oxygen levels, increased acidity, and other water chemistry changes that may be lethal to mussels (Horne and McIntosh 1979, Rand and Petrocelli 1985, Sheehan et al. 1989, Keller and Zam 1991, Dimock and Wright 1993, Goudreau et al. 1993, Jacobson et al. 1993, Keller 1993).Sediment from the upper Clinch River, where several of these species occur, was found to be toxic to juvenile mussels (Robison et al. 1996). Ahlstedt and Tuberville (1997)speculated that the presence of toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream. Wilcoveand Bean (1994) reported that studies indicated that mussel reproduction below the site of the Appalachian Power Company's (APCO) electric generating station in Carbo,Virginia, was being inhibited by copper discharges. In addition, copper was shown to be toxic to mussels at levels below the U.S. Environmental Protection Agency (EPA) criteria established in Virginia. The Virginia State Water Control Board began proceedings to impose a special water quality standard for copper below the plant. In 1992, the State and APCO agreed on a lower standard for copper for this specific stretch of the Clinch.APCO is spending several million dollars to control copper discharge from its facility to meet the new standard (Wilcove and Bean 1994). Although the Clean Water Act (CWA), administered by the EPA, has helped eliminate many point-source effluents, "straight pipes" (pipelines conveying untreated householdeffluents; e.g., chlorine, detergents, household chemicals, human waste, etc., from rural homes directly into streams) continue to discharge wastes. Fraley and Ahlstedt (2000) thought that effluents from straight pipes were partially to blame for the documented decline of the native mussel fauna in Copper Creek from 19 species in 1980 to 11 species in 1998. Included in the historical Copper Creek fauna were the oyster mussel, rough rabbitsfoot, and purple bean, although only the latter species was found live in 1998.Numerous other streams in the Cumberlandian Region doubtless also have straight pipes discharging pollutants into mussel habitat. Agricultural sources of chemical contaminants are considerable and include two broad categories--nutrients and pesticides (Frick et al. 1998). Nutrient enrichment generally occurs as a result of runoff from livestock farms and feedlots and from fertilizers used on row crops. Various OWCs may also be associated with livestock concentrations (Kolpin et al. 2002). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated, resulting in overenrichment, a condition exacerbated by low-flow conditions. Excessive stands of filamentous algae, acommon manifestation of overenrichment, alter the surface of the stream bottom and may represent a shift in algal communities that could disrupt, particularly, juvenile mussel food supplies. Juvenile mussels, utilizing interstitial habitats, are particularly affected by excessive levels of algae-consuming dissolved oxygen during nocturnal respiration (Sparks and Strayer 1998). Increased risks from bacterial and protozoan infections to eggs and glochidia may also pose a threat (Fuller 1974). Hoos et al. (2000) summarized data on nutrient loading in the lower Tennessee River system, where overenrichment was the cause of impairment in 37 stream segments. Nonpoint sources, primarily agricultural inputs, accounted for the largest percentage of total nitrogen and total phosphorus in all streams tested in the study area. Relatively high levels of nutrients were prevalent in the Duck River, where a large population of the oyster mussel occurs. Nutrient levels were also analyzed in the upper Tennessee River system by Hampson et al. (2000). Overall, nutrient concentrations were generally lower than national concentrations and were relatively high only on a localized scale. Secondly, pesticides, primarily from row c

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Sedimentation is widely thought to have contributed to the decline of mussel populations (Kunz 1898; Ellis 1931, 1936; Cordone and Kelly 1961; Imlay 1972; Coon et al. 1977; Marking and Bills 1979; Wilber 1983; Dennis 1985; Schuster et al. 1989; Wolcott and Neves 1990; Houp 1993; Richter et al. 1997, Brim Box 1999; Henley et al. 2000; Fraley and Ahlstedt 2000). Specific biological impacts on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates,

increased substrate instability, limited burrowing activity, and physical smothering (Ellis 1936, Stansbery 1971, Markings and Bills 1979, Kat 1982, Vannote and Minshall 1982, Aldridge et al. 1987, Waters 1995). Brim Box (1999) showed that burying adult mussels under 5.5 inches of sediment in the Apalachicola, Chattahoochee, and Flint River basin significantly decreased their chances of surviving. Intuitively, much thinner layers of sediment may result in juvenile mortality. Some studies tend to indicate that the primary impacts of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999). The physical effects of sediment on mussels appear to be multifold (Brim Box and Mossa 1999). They are potentially impacted by changes in suspended and bed material load; bed sediment composition associated with increased sediment production and runoff in the watershed; channel changes in form, position, and degree of stability; changes in depth or the width/depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave them high and dry (Vannote and Minshall 1982, Kanehl and Lyons 1992, Hartfield 1993, Brim Box and Mossa 1999; see earlier discussion on “Gravel Mining”). Interstitial spaces in mixed substrates may become clogged with sediment (Gordon et al. 1992). When clogged, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999), thus reducing habitat for juvenile mussels and some adults as well. Salomons et al. (1987) and the National Research Council (1992) indicated that sediment may act as a vector for delivering contaminants such as nutrients and pesticides to streams. Juveniles can readily ingest contaminants adsorbed to silt particles during normal feeding activities (see “Food Habits”). These factors may help explain, in part, why so many mussel populations appear to be experiencing recruitment failure. Host fish/mussel interactions may be indirectly impacted by changes in stream sediment regimes through three mechanisms (Brim Box and Mossa 1999). First, fish abundance (Berkman and Rabeni 1987), diversity (Waters 1995), and reproduction (Muncy et al. 1979) may be reduced with increased sedimentation. Second, excessive sedimentation likely impedes host fish attractant mechanisms (e.g., mantle flaps, conglutinates, superconglutinates that mimic fish prey items; see “General Reproductive Biology of Mussels”) (Haag et al. 1995, Burkhead et al. 1997). Third, sedimentation on shoal substrates may interfere with the ability of some species’ adhesive conglutinates to adhere to rock particles (Hartfield and Hartfield 1996). Many Southeastern streams have increased turbidity levels due to siltation (van der Schalie 1938). Some of these five species attract host fishes with visual cues, luring fish into perceiving that their glochidia are prey items (see “Reproductive Biology of the Five Species”). Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991) and may have contributed to population declines in some of these mussel species. In addition, mussels may be indirectly affected when turbidity levels significantly reduce the amount of light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992). Agricultural activities produce the most significant amount of sediment that enters streams (Waters 1995). Neves et al. (1997) stated that agriculture (including both sediment and chemical runoff) affects 72 percent of the impaired river miles in the country. Unfortunately, the CWA does not regulate agricultural runoff, return waters, or discharge flows (D. Powell, EPA, letter dated June 20, 2003). Armour et al. (1991) reviewed the effects of livestock grazing on riparian and stream ecosystems. Unrestricted access by livestock is a significant threat to streams (Trimble and Mendel 1995) and their mussel populations throughout much of the Cumberlandian Region (Anonymous 1999, Fraley and Ahlstedt 2000). Grazing may reduce infiltration rates and increase runoff and erosion (Brim Box and Mossa 1999). Trampling causes or accelerates stream-bank erosion, and grazing reduces a bank’s resistance to erosion (Armour et al. 1991, Trimble and Mendel 1995). In addition, livestock may add nutrients to streams at levels that are not easily assimilated, particularly during low-flow conditions, resulting in overenrichment. Fraley and Ahlstedt (2000) attributed the decline of the Copper Creek mussel fauna between 1980 and 1998, among other factors, to an increase in cattle grazing and loss of riparian vegetation in the stream. They considered the oyster mussel and rough rabbitsfoot as possibly being extirpated from Copper Creek. Erosion from silvicultural activities accounts for 6 percent of the nation's sediment pollution (Henley et al. 2000). Sedimentation impacts are more the result of logging roads than the actual harvesting of timber (Waters 1995, Brim Box and Mossa 1999). Developmental activities associated with urbanization (e.g., highways, building construction, infrastructure creation, recreational facilities) may contribute significant amounts of sediment and other pollutants in quantities that may be detrimental to stream habitats (Waters 1995, Couch and Hamilton 2002). Urban development changes sediment regimes by creating impervious surfaces and drainage system installations (Brim Box and Mossa 1999). The highest erosion rates are generally associated with construction activities, which can contribute sediment at a rate 300 times greater than from forested land (USDA 1977). Stream channel erosion contributes up to two-thirds of the total sediment yield in urbanized watersheds (Trimble 1997). With development, watersheds become more impervious, resulting in increased storm-water runoff into streams (Myers-Kinzie et al. 2002) and a doubling in annual flow rates in completely urbanized streams (DeWalle et al. 2000). Impervious surfaces may reduce sediment input into streams but result in channel instability by accelerating storm-water runoff, which increases bank erosion and bed scouring (Brim Box and Mossa 1999). Stream channels become highly unstable as they respond to increased flows by incising, which increases shear stress and bed mobilization (Doyle et al. 2000). With increasing shear stress, benthic organisms become increasingly dislodged downstream (Myers-Kinzie et al. 2002). Studies have indicated that high shear stress is associated with low mussel densities (Layzer and Madison 1995) and that peak flows and substrate movement limits mussel communities, particularly at the juvenile stage (Myers-Kinzie et al. 2002). For some of these species, a considerable amount of habitat has been lost, particularly in metropolitan areas in Tennessee (e.g., Knoxville, Nashville, Chattanooga). Streams that contain these five species, and which are currently threatened with development activities, include Sinking Creek (potential interstate highway, industrial park; Cumberland elktoe) and Buck Creek (potential interstate highway, Cumberlandian combshell), Kentucky; Bear Creek, (instream gold mining, Cumberlandian combshell), Alabama and Mississippi; and the Duck River (general development from rapid growth, oyster mussel) Tennessee (Butler, pers. obs., 2002; Cicerello, pers. comm., 2003; L. Colley, TNC, pers. comm., 2002). Water withdrawa

Stressor: Predation
Exposure:
Response:
Consequence:
Narrative: Muskrat predation is one factor limiting the Cumberland elktoe.

Stressor: Invasive Species
Exposure:
Response:
Consequence:
Narrative: The asian clam has been implicated as a competitor with native mussels for resources such as food, nutrients, and space (Heard 1977, Kraemer 1979, Clarke 1986), particularly as

juveniles (Neves and Widlak 1987). According to Strayer (1999b), dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles. Periodic dieoffs may produce enough ammonia and consume enough oxygen to kill native mussels (Strayer 1999b). The invasion of the nonnative zebra mussel (Dreissena polymorpha [Pallas, 1773]) poses a threat to the mussel fauna of the Cumberlandian Region (Ricciardi et al. 1998). Zebra mussels in the Great Lakes have attached, in large numbers (up to 10,000 per unionid), to the shells of live and fresh dead native mussels (Schlosser and Kovalak 1991), and they have been implicated in the loss of mussel beds (Hunter and Bailey 1992, Masteller et al. 1993, Schlosser and Nalepa 1995). Although zebra mussels are now in the Tennessee and Cumberland River systems, the extent to which they will impact native mussels is unknown.

Stressor: Dissolved Solids
Exposure:
Response:
Consequence:
Narrative: While oil and gas development and coal mining were listed as threats to the Cumberland elktoe in both the Recovery Plan and the last 5 year review, new research is beginning to shed light on the specific chemical constituents primarily responsible for declines in freshwater mussels, such as the Cumberland elktoe. In sites impacted by coal mining or natural gas extraction, total recoverable metals, PAHs, major ions, or a combination of the three have contributed to sediment toxicity and mussel declines in the Upper Tennessee and Cumberland River basins (Wang et al. 2013). Oil and gas wastewater from both conventional and unconventional wells have been shown to be a risk to aquatic organisms due to halide and ammonium levels in these waters, even after brine treatment (Harkness et al., accepted 2014). Price et al. (2014) found a temporal increase of dissolved solids in the Clinch River between 1964 and 2010 that corresponds to declining mussel densities in the Virginia portion of the river. In addition, water-column ammonia and sediment metals have occurred at levels likely contributable to the decline of freshwater mussels in the Virginia portion of the Clinch River (Price et al. 2014). The increased levels of ammonia, metals, and dissolved solids were seen in watersheds drained by both agricultural activity and coal mining, however, mussel declines are greater in close proximity to and downstream of watersheds impacted by coal mining (Guest River tributary to the Clinch River) (Price et al. 2014) (USFWS, 2015).

Stressor: Climate Change (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Small and isolated Cumberland elktoe populations are less resilient to natural stochastic events (e.g., floods, drought, etc.) (Hastie et al. 2001; Haag and Warren 2008). Haag and Warren (2008) documented mussel declines of 65-83 percent in small streams in the Bankhead National Forest in Alabama following extreme drought in 2000. McGregor (2019) suggested the drought in 2016 may have similarly contributed to the loss of Cumberland elktoe in North White Oak and many other smaller tributary sites. During the 2016 drought, water levels were at record lows (< 3 cubic feet per second), and temperatures exceeded 30°C for an extended period (McGregor 2019). Several studies have been conducted in recent years on thermal tolerances of freshwater mussels and their hosts. Pandolfo et al. (2012) examined 10 species of mussels and found both glochidia and juvenile mussels had LT50s (lethal temperature

for 50 percent of test subjects) ranging between 21.1°C -38.1°C with a mean of 33.1°C. Fish hosts also had similar thermal tolerance values in that study, ranging between 23.5°C -38.1°C with a mean of 33.1°C. Recruitment can also be impacted by drought conditions, Layzer and Moles (2009) indicated that low recruitment of Cumberland elktoe occurred during the three drought years preceding 1988 and two drought years preceding 2008 in North Prong Clear Fork and Bone Camp Creek, but recruitment was relatively strong in the years before and after drought (USFWS, 2022).

Recovery

Reclassification Criteria:
The Cumberland elktoe will be considered for reclassification to threatened status when the likelihood of their becoming extinct in the foreseeable future has been eliminated by achieving the following criteria: a. At least five distinct viable stream populations of the Cumberland elktoe in the Cumberland River system. This will be accomplished by: (1) Protecting all extant stream populations (i.e., Laurel Fork, Marsh Creek, Sinking Creek, Big South Fork system, Rock Creek) and ensuring that all of these streams have viable population status. 2. One distinct naturally reproduced year class exists within each of the viable populations. The year class must have been produced within 5 years prior to the time the species are reclassified from endangered to threatened. Within 1 year before the downlisting date, gravid females of the mussels and their host fish must be present in each viable population. 3. Research studies of the mussels' biological and ecological requirements have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful (see Recovery Tasks 1.4.1, 1.4.2, 1.4.5, and 1.4.6), as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring (see Recovery Task 5). 4. No foreseeable threats exist that would likely impact the survival of any of the species over a significant portion of their ranges (see Recovery Tasks 1.4.3 and 1.4.4). 5. Within larger streams (e.g., Rockcastle River, Big South Fork, Clinch River, Powell River, upper Holston River/North Fork Holston River, Elk River, Duck River, Buffalo River), the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable (see Recovery Task 4.1). 6. Biennial monitoring of the five species yields the results outlined in "criterion 1. a-e" over a 10-year period (see Recovery Task 5).

Recovery Priority Number: 5

Delisting Criteria:
The Cumberland elktoe will be considered for removal from the Federal List of Endangered and Threatened Wildlife and Plants when the likelihood of their becoming endangered in the foreseeable future has been eliminated by achieving the following criteria: 1. Through the protection of extant stream populations (e.g., continuing to use existing regulatory mechanisms, establishing partnerships with various stakeholders, using BMPs, minimizing or eliminating threats), discovery of currently unknown stream populations, and/or reestablishment of historical stream populations, there exists: a. At least seven distinct viable stream populations of the Cumberland elktoe in the upper Cumberland River system. This will be accomplished by: (1) Protecting all extant stream populations (i.e., Laurel Fork, Marsh Creek, Sinking Creek, Big South Fork system, Rock Creek) and ensuring that all of these streams have viable population status.

(2) Establishing a distinct viable stream population in one additional stream in the upper Cumberland River system. 2. Two distinct naturally reproduced year classes exist within each of the viable populations. Both year classes must have been produced within 10 years, and one year class must have been produced within 5 years of the recovery date. Within 1 year before the recovery date, gravid females of the mussels and their host fish must be present in each viable population. 3. Research studies pertaining to the mussels' biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful (see Recovery Tasks 1.4.1, 1.4.2, 1.4.5, and 1.4.6), as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited in each of the viable populations as determined through biennial monitoring (see Recovery Task 5). 4. No foreseeable threats exist that would likely threaten the survival of any of the viable populations (see Recovery Tasks 1.4.3 and 1.4.4). 5. Within larger streams (e.g., Rockcastle River, Big South Fork, Clinch River, Powell River, upper Holston River/North Fork Holston River, Elk River, Duck River, Buffalo River), the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable (see Recovery Task 4.1). 6. Biennial monitoring of the five species yields the results outlined in "criterion 1. a-e" above over a 10-year period (see Recovery Task 5).

Recovery Actions:

- 1. Utilize existing legislation/regulations to protect current and newly discovered populations.
- 2. Determine the species' life history requirements and threats and reduce or alleviate those threats which threaten the species.
- 3. Develop and use an information/education program to solicit the assistance of local landowners, communities, and others to recover the species.
- 4. Search for additional populations, and through propagation activities, pursue augmentations or reintroductions in order to establish viable populations.
- 5. Conduct anatomical and molecular genetic analysis of the species to determine the potential occurrence of species complexes or hidden biodiversity.
- 6. Develop and implement a monitoring program, and annually assess the recovery program where needed.
- Conduct a trial reintroduction of the Cumberland elktoe into its historical range in the Cumberland River system above Cumberland Falls (Cumberlandian Region Mollusk Restoration Committee 2010) (USFWS, 2015).

References

Final listing for critical habitat

Recovery Plan

Five year review

nature serve

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered Mussels in the Tennessee and Cumberland River Basins. Final rule. 69 FR 53136 - 53180 (August 31, 2004).

Five year Review

Nature Serve

Nature Serve USFWS. 2015. 5-YEAR REVIEW of Cumberland Elktoe (Alasmidonta atropurpurea). U.S. Fish and Wildlife Service. 2015. Cookeville Ecological Services Field Office. Cookeville, Tennessee. USFWS. 2022. Cumberland Elktoe (Alasmidonta atropurpurea) 5-Year Review: Summary and Evaluation. Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 23 pp.

USFWS. 2015. 5-YEAR REVIEW of Cumberland Elktoe (Alasmidonta atropurpurea). U.S. Fish and Wildlife Service. 2015. Cookeville Ecological Services Field Office. Cookeville, Tennessee.

USFWS. 2022. Cumberland Elktoe (Alasmidonta atropurpurea) 5-Year Review: Summary and Evaluation. Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 23 pp.

SPECIES ACCOUNT: *Alasmidonta heterodon* (Dwarf wedgemussel)

Species Taxonomic and Listing Information

Commonly-used Acronym: DWM

Listing Status: Endangered

Physical Description

This species is a freshwater mussel. The species name heterodon refers to the chief distinguishing characteristic of this species, which is the only North American freshwater mussel that consistently has two lateral teeth on the right valve, but only one on the left (Fuller 1977). It is a small mussel whose shell rarely exceeds 1.5 inches in length. The species exhibits strong sexual dimorphism with females showing posterior inflation of the shell to accommodate the marsupial gills.

Taxonomy

Preliminary research indicates that there is some question as to the phylogenetics of the Anodontinae, the subfamily in which the dwarf wedge mussel is found (King et al. 2006). Further phylogenetic review of the dwarf wedge mussel and other species within the Anodontinae wil be necessary to confirm the current nomenclature of the dwarf wedge mussel.

Historical Range

The dwarf wedge mussel was once widely distributed in river systems of the Atlantic slope from New Brunswick, Canada, south to the Neuse River system in North Carolina.

Current Range

The dwarf wedge mussel is found solely in Atlantic Coast drainage streams and rivers of various sizes and moderate current. It ranges from New Hampshire to North Carolina, in small creeks to deep rivers in stable habitat with substrates ranging from mixed sand, pebble and gravel, to clay and silty sand.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Its reproductive cycle is typical of other freshwater mussels, requiring a host fish on which its larvae parasitize and metamorphose into juvenile mussels. The DWM is not a long-lived species as compared to other freshwater mussels; life expectancy is estimated at 10 to 12 years. The tessellated darter (Etheostoma olmstedi), Johnny darter (e. nigrum), and mottled sculpin (Cottus bairdi) serve as host fish for DWM in the southern part of its range. The slimy sculpin (C. congatus) and juvenile and parr of the Atlantic samon (Salmo salar) serve as host fish for the DWM in New Hamshire. The DWM is considered to be a long-term brooder. In general, DWM glochidia may be released beginning in March and continuing through June in the Ashuelot River in New Hampshire. In a study of DWM reproduction in the Mill River, Massachusetts, most glochidia were observed being released in April and May.

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The dwarfwedge mussel lives on muddy sand, sand, and gravel bottoms in creeks and rivers of varying sizes, in areas of slow to moderate current and little silt deposition.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Some are stable and some are declining. Populations in NC, VA, and MD appear to be declining, and poulations in NH, MA, and CT appear to be stable.

Species Trends:

unknown

Population Growth Rate:

unknown

Number of Populations:

uncertain; inconsistent use of sites and occurences; populations need to be better defined

Population Size:

100,000 - 1,000,000 individuals

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

At one time, this species was recorded from 70 localities in 15 major drainages ranging from North Carolina to New Brunswick, Canada. Since the 1993 recovery plan was written, a number of new locations have been discovered and a number of known locations are possibly no longer extant. Based on preliminary information, the DWM is currently found in 15 major drainages, comprising approximately 70 sites. At least 45 of these sites are based on less than five individuals or solely on spent shells. The only known occurrence in New Brunswick, Canada appears to be historic; no live mussels or spent shells were found during surveys. The mainstem of the Connnecticut River in New Hampshire and Vermont is considered to have the largest remaining DWM population, consisting of three distinct stretches of sporatically occupied habitat segmented by hydroelectric dams. It is estimated that there are hundreds or thousands of DWM scattered within an approximate 75-mile stretch of the Connecticut River. The Ashuelot River in New Hampshire , the Farmington River in Connecticut, and the Neversink River in New York harbor large populations, but these number in the thousands only. The remaining populations from New Jersey south to North Carolina are estimated at a few individuals to a few hundred individuals. In summary, it appears that the populations in North Carolina, Virginina, and Maryland are declining as evidenced by low densities, lack of reproduction, or inability to relocate any DWM in follow-up surveys. Populations in New Hampshire, Massachusetts, and Connecticut appear to be stable, while the status of populations in the Delaware River watershed is uncertain at this time. Studies have begun investigating the genetic structure of DWM with a focus on determining the genetic relatedness of disjunct populations within the Delaware River watershed and among watersheds, including the Connecticut Rver, the Delaware River, the Potomac River, and the Tar River. Preliminary information suggests that: 1) there are observable population structure differences among the isolated population in the Delaware River watershed, and (2) rangewide, northern and southern regions are distinguishable, although the level of genetic divergence is limited. Since the DWM was listed, new and large populations in the Connecticut and Delaware River watersheds have been discovered. The species should be considered stable in the northern extent of its range in New Hampshire and Connecticut, based on population numbers and extent of occupied habitat. However, little riverine habitat is protected, and the populations remain vulnerable to water quality degradation. A number of sites in Maryland, Virginia, and North Carolina appear to be extirpated or in severe decline.

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The damming and channelization of rivers throughout the species’ range has resulted in the elimination of much formerly occupied habitat. For example, dams have converted much of the Connecticut River mainstream into a series of impoundments (Master 1986). Immediately upstream from each dam, conditions (including heavy silt deposition and low oxygen levels) are inimical to mussel species such as the dwarf wedge mussel. Immediately downstream from these dams, daily water level and water temperature fluctuations resulting from intermittent power generation and hypoliunetic discharges are also stressful to mussels (Master 1986). Some extreme variations in flow have been observed below dams on the Ashuelot River in New Hampshire. Master (1992) indicates that mollusks, including the dwarf wedge mussel, have been stranded by extreme low water on two recent occasions — once when water discharge was lowered from over 100 CFS to 10 CFS in one day, and once in the summer of 1991 when a dam in Keene was under repair. Hypolimnial discharges from reservoirs produce cold tailwater conditions that alter the typical fish and benthic assemblages (Fuller 1974). Fuller stressed that these changes associated with inundation adversely affect both juvenile and adult mussels and also alter the native fish fauna, eliminating possible fish hosts for glochidia. Effects of dams on mussel habitat have not been entirely adverse. Some water supply reservoirs have protected watersheds and, therefore, high quality waters downstream. Populations of dwarf wedge mussels and other mussel species are often especially dense below mill dams and beaver dams.

Stressor: Pollution

Exposure:
Response:
Consequence:
Narrative: The continuing decline and ultimate loss of the dwarf wedge mussel from most of its historical sites can best be explained by agricultural, domestic, and industrial pollution of its aquatic habitat. Mussels are known to be sensitive to potassium (a common pollutant associated with paper mills and irrigation return water), zinc, copper, cadmium, and other elements (Havlik and Marking 1987). Pesticides, chlorine, excessive nutrients, and silt carried by agricultural runoff also present a threat to this species. No mussels survive in several large, undammed sections of the Connecticut and Delaware River drainages where water pollution has exacted a heavy toll on the benthic fauna. Even where water quality has improved, as in the lower Connecticut River, chemicals trapped in the sediments inhabited by mussels may impede the recovery of sensitive species (Master 1986). One of the largest known remaining populations of the dwarf wedge mussel occurs where the Ashuelot River meanders through a golf course. This population has undergone a dramatic decline over the past 10-30 years. The continuing decline of the dwarf wedge mussel at this site, particularly downstream of the golf course, may well be attributed to fungicides, herbicides, insecticides, and fertilizers applied to the golf course and to agricultural runoff from abutting corn fields and pastures (Master 1986). It has been suggested that elevated cadmium levels, which have been found in the Ashuelot for short periods of time, may also be a contributing factor in this decline. In this case, the elevated cadmium levels appear to result from cleaning the gates on the Surry Mountain Dam, just upstream of the mussel population. Pollutants may also affect the mussels indirectly; nitrogen and phosphorus input cause organic enrichment and, if extreme, oxygen depletion. Acid rain may mobilize toxic metals and lead to decreased alkalinity which is inimical to most mussels. Increased acidity may have contibuted to the recent decline of the dwarf wedge mussel in the Fort River in Massachusetts. Several studies have investigated the effects of specific chemicals and heavy metals on mussels. Fuller (1974) reviewed the effects of arsenic, cadmium, chlorine, copper, iron, mercury, nitrogen, phosphorus, potassium, and zinc on naiads. Of the heavy metals, zinc was noted as the most toxic, whereas copper, mercury, and silver were less harmful. Goudreau (1988) studied the effects on aquatic mollusks of chlorinated effluent from sewage treatment plants. She found that recovery of mollusk populations may not occur for up to two miles below the discharge point. Imlay (1973) studied the effects of different levels of potassium, an industrial pollutant associated with paper mills, irrigation return water, and petroleum brine. The maximum level of potassium which most mussel species could tolerate was 4 to 10 mg/l. Salanki and Varanka (1978) found that insecticides have significant effects on mussels. Low concentrations of lindane (.006 gIl), phorate (.008 g/l), and trichlorfon (.02 g/l) caused a 50 percent reduction in siphoning activity, and 1 g/l phorate or 1 ml/l trichlorfon were lethal concentrations. Recent studies on contaminants have focused primarily on heavy metal effects on mussels. Mathis and Cummings (1973) investigated concentrations of certain heavy metals (copper, nickel, lead, chromium, zinc, cobalt, cadmium) in the sediments, water, mussels, fishes, and tubificids in the Illinois River. Mussels analyzed (Fusconaia flava, Amblema olicata, Ouadrula auadrula) contained higher concentrations of all metals than the water and lower concentrations than sediments. Mussels concentrated zinc to a greater degree than fishes or tubificids; all other metals were accumulated to intermediate concentrations. Salanki and Varanka (1976) found that the rhythmic activity (siphoning) of hn~2nL~ ~ygn~ was reduced by 10 percent when exposed to l0~'~ zw/l of copper sulfate, tne chemical was lethal at 10 mg/l. Havlik and Marking (1987) indicated that long-term exposure of mussels to concentrations of copper as low as 25 parts per billion (ppb) was lethal. Salanid (1979) investigated the behavior of Anodonta ~ygn~, subjected to certain heavy metals (mercury and

cadmium), herbicides, and pesticides (paraquat, lindane, phosphamidon, and phorate). The siphoning period of this species was reduced at some concentrations and the metabolic rate decreased. Manly and George (1977) collected Anodonta anatina from the River Thames and determined the distribution of zinc, nickel, lead, cadmium, copper, and mercury in body tissues. Zinc and copper were most highly concentrated in the mantle, ctenidia (gills), and kidneys; nickel levels were highest in the kidneys; lead in the digestive gland and kidneys; cadmium in the ctenidia, digestive gland, and gonads; and mercury in the kidneys. Recent studies by Keller and Zam (1991), using juvenile Anodonta spp., have shown that freshwater mussels are quite sensitive to metal pollution. Acute toxicity tests, using juvenile mussels reared in the laboratory, were performed for the following six metals: cadmium, chromium, copper, mercury, nickel, and zinc. Keller and Zam concluded that, overall, mussels were as sensitive to metals as DaDhnia, but more sensitive than commonly tested fish and aquatic insects (Table 2).

Stressor: Riverbank alteration
Exposure:
Response:
Consequence:
Narrative: Land use changes throughout watersheds supporting the dwarf wedge mussel, especially along riparian corridors, may affect the species in a multitude of ways. The removal of streambank vegetation affects both the physical and biological processes of the waterways. Tree removal alters the amount of organic material and light reaching the stream, impacting both temperature and dissolved oxygen, which are critical factors for both fish and mussels. The floodplain biomass can also help buffer the stream from pollutants.

Stressor: Siltation
Exposure:
Response:
Consequence:
Narrative: Siltation, generated by road construction, agriculture, forestry activities, and removal of streambank vegetation is considered to be an important factor in the decline of many freshwater mussel species, including the dwarf wedge mussel. Sediment loads in rivers and streams during periods of high discharge may be abrasive to mollusk shells. Erosion of the periostracum allows carbonic and other acids to reach and corrode underlying shell layers (Harman 1974). Feeding mollusks respond to heavy siltation by instinctive closure of their valves, since irritation and clogging of the gills and other feeding structures occurs when suspended sediments are siphoned from the water column (Loar ~ ni. 1980). Although mussels possess the ability to secrete mucus to remove silt from body tissues, Ellis (1936) observed dying mussels with excessive quantities of silt in their gills and mantle cavities. Freshwater mussels are long-lived and sedentary, with limited ability to move to more favorable habitats when silt is deposited over mussel beds. Ellis (1936) found that mussels could not survive in substrate on which silt (0.6-2.5 cm) was allowed to accumulate; death was attributed to interference with feeding and to suffocation. In this same study, Ellis determined that siltation from soil erosion reduced light penetration, altered heat exchange in the water, and allowed organic and toxic substances to be carried to the bottom where they were retained for long periods of time. This resulted in further oxygen depletion and possible absorption of these toxicants by mussels (Harman 1974). Erosion and siltation resulting from land clearing and grading, and construction of bridges, roads, and other structures may be especially damaging to the dwarf wedge mussel ‘s habitat. For instance, in Massachusetts, a dwarf wedge mussel population was decimated in one

small stream when “... the construction of a small bridge resulted in accelerated sedimentation and erosion which buried and killed many of the bivalvest’ (Smith 1981). Paradoxically, some bank erosion control measures such as riprapping may also adversely affect the species. A significant portion of one of the extant Connecticut River populations was eliminated in 1987 by burial under rock riprap placed along the shore of a Vermont State Park.

Stressor: Small and isolated populations
Exposure:
Response:
Consequence:
Narrative: Most of the dwarf wedge mussel populations are small, and all are geographically isolated from each other. This isolation restricts the natural interchange of genetic material between populations. The small population size also reduces the reservoir of genetic variability within populations. It is likely that several of these populations are now below the level required to maintain long-term genetic viability. Furthermore, the small size of many of the dwarf wedge mussel’s populations makes the species especially vulnerable to overcollecting.

Stressor: Flooding
Exposure:
Response:
Consequence:
Narrative: Recent, severe flooding in the Delaware and Neversink Rivers in Pennsylvania and New York, respectively, resulted in the destruction of occupied habitat and loss of habitat and loss of dwarf wedgemussels.

Stressor: Invasive species
Exposure:
Response:
Consequence:
Narrative: The invasion of the Asian clam (Corbicula fluminea) may be a significant threat to the dwarf wedge mussel. The Asian clam is one of 204 introduced mollusk species in North America (Dundee 1969). It was first discovered in the United States in the Columbia River, Oregon, in 1939. It appeared in’California in the 1940’s and 1950’s, in the Ohio/Mississippi and Gulf of America drainages in the 1960’s and 1970’s, and in the Atlantic drainage in the 1970’s and 1980’s (Clarke 1988). Once established in a river, Corbicula fluminea populations achieve high densities and expand rapidly. Densities of 1,000/rn2 in the James River, Virginia (Diaz 1974), the New River, Virginia (Rodgers et al. 1977), and the Tar River, North Carolina (Clarke 1983), and densities of 10,000/rn2 in the Altanaha River in Georgia (Gardner ~ ~. 1976) have been reported. Clarke (1988) indicates that Corbicula was first introduced into the James River in 1971 near Hopewell, Virginia, about 15 miles below Richmond, and by 1984 had spread 195 miles upstream (an average of 15 miles per year). Malacologists are now concerned about the possibility of a competitive interaction between Asian clams and native bivalves. Quantitative studies by Cohen ~ ~j. (1984) support the hypothesis that an extensive C. fluminea bed in a reach of the Potomac River removed 40-60% of the phytoplankton in this reach. It is not unreasonable to conclude that C. fluminea has the potential to deplete the food supply of unionids. A similar threat may be posed by the recent invasion of the zebra mussel (Dreissena ~olvmorDha). Although not yet known to be present in any of the rivers supporting the dwarf wedge mussel, the zebra mussel is expanding its range rapidly and can be expected to arrive in some of these rivers in the near

future. Mussel die-offs, the cause of which remains unknown may be a threat to the dwarf wedge mussel. Since 1982 biologists and commercial musselmen have reported extensive mussel die-of fs in rivers and lakes throughout the United States. Kills have been documented from the Clinch River (Virginia), Powell River (Virginia, Tennessee), Tennesee River (Tennessee), Grand River (Oklahoma), the Upper Mississippi River (Wisconsin to Iowa), and rivers in Illinois, Kentucky, and Arkansas (USFWS 1987). Lake St. Clair (Michigan), Chatauqua Lake (New York), and Court Oreilles Lac (Wisconsin) have also been affected. The cause is unknown, but numerous species of mussels are involved, including several commercially important and Federally listed species (USFWS 1987). A large mussel die-off has occurred in at least one river supporting the dwarf wedge mussel — the Tar River in North Carolina. Personnel involved in a survey for the endangered Tar River spinyrnussel in April 1986 dicovered hundreds of freshly dead and recently dead juvenile and adult mussels of various species at two locations in the Tar River below Rocky Mount, North Carolina (USFWS 1987).

Stressor: Climate Change (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: The 2013 review identified potential effects of climate change on the DWM. The following is a summary of additional relevant information. Schlesinger et al. (2011) assessed multiple NY species vulnerability to climate change and described the DWM as extremely vulnerable4 to climate change. Pennsylvania Natural Heritage Program (2011) assessed the DWM as highly vulnerable5 to climate change. They found that the limited dispersal capabilities, sensitivities to changes in precipitation, natural and anthropogenic barriers, and human responses to climate change increase the DWM's vulnerability. Poff et al. (2002) found that the likely impacts of climate change on aquatic systems include increases in water temperatures. They also found that changes and shifts in seasonal patterns of precipitation and runoff will alter the hydrology of stream systems, affecting species composition and ecosystem productivity. Aquatic organisms are sensitive to changes in frequency, duration, and timing of extreme precipitation events such as floods or droughts, potentially resulting in interference with reproduction. Further, increased water temperatures and seasonally reduced stream flows will alter many ecosystem processes. Since sedentary freshwater mussels have limited refugia from disturbances such as droughts and floods, and since their physiological processes are constrained by water temperature within species-specific thermal preferences, changes in water temperature can lead to shifts in mussel community structure (Galbraith et al. 2010). Daraio et al. (2014) modeled temperature changes in the upper Tar River basin and found that temperatures are likely to impact larval and juvenile mussels (including the DWM) within the next 50 years by exceeding their known thermal tolerances. Regional assessments, which summarized trends in climate variables (NOAA 2013a and 2013b) and vulnerabilities of fish and wildlife habitat to climate change (Manomet Center for Conservation Sciences and National Wildlife Federation 2013, entire) have provided broad patterns that may also be useful to predict impacts to the DWM from climate change. For the Northeast and MidAtlantic (excluding Virginia), NOAA (2013a) evaluated regional climate trends and future emission scenarios. Key findings include (NOAA 2013a, p. 72-74): Climatic events of concern in the northeast include flooding, winter storms (e.g., nor'easters, lake-effect snow, ice), heat waves, and drought. Temperatures have increased since 1960, especially in winter and spring seasons, and temperatures are expected to continue to increase. Annual precipitation has been more variable since 1970. Precipitation is expected to increase over the regions except in the southern areas where the direction of change

is unclear. Seasonally, precipitation is expected to increase in the winter, spring, and fall, but decrease in the summer. Overall, there is considerable uncertainty associated with predicting precipitation changes. ▯ Climatic events of concern in the southeast include heavy rainfall and floods, drought, temperature extremes, and severe storms (NOAA 2013b, pp 83-85). ▯ The Southeast has not exhibited a warming trend over the 20th century. Projections indicate significant future warming; however, projections show substantial uncertainty in the magnitude of temperature change within the region. Projected temperature changes are similar for high and low emission scenarios out to the mid-century but deviate into the late-century period where warming under the high emission scenario is expected to be twice that for the low emission scenario. ▯ Precipitation is expected to generally increase, especially in the north and east of the region within the range of the DWM. The Appalachian Mountains are expected to experience an increase in the number of days with precipitation exceeding 1 inch. The number of consecutive days with precipitation less than 0.1 inches is expected to have little or no change. In summary, climate change is expected to impact the DWM as a result of increased heavy rainfall, drought, and temperature changes. (USFWS, 2019)

Recovery

Reclassification Criteria:
In order to reclassify the dwarf wedge mussel as threatened from endangered, this criterion must be met: 1) The following populations of dwarf wedge mussel must be shown to be viable (a population containing a sufficient number of reproducing adults to maintain genetic variability, and annual recruitment is adequate to maintain a stable population): Mainstem Connecticut River, Ashuelot River, Neversink River, Upper Tar River, Little River, Swift Creek, Turkey Creek, and six other rivers/creeks representative of the species' range.

Delisting Criteria:
In order to remove the dwarf wedge mussel from the federal list of threatened and endangered species, the following criteria must be met: 2) at least 10 of the rivers/creeks in Criterion 1 must support a widely dispersed viable population so that a single catastrophic event in a given river will be unlikely to result in the total loss of that river's population. 3) The rivers in Criterion 2 should be distributed throughout the species' current range with at least two in New England (NH, VT, MA, CT), one in New York, and four south of Pennsylvania. 4) All populations referred to in Criteria 1 and 3 must be protected from present and foreseeable anthropogenic and natural threats that could interfere with their survival.

Recovery Actions:
- 3) Identify high priority populations needed for the recovery of the species (if recovery plan revision does not proceed quickly).
- 4) Develop habitat protection strategies for high priority populations.
- 5) Encourage and support publication of gray literature in peer-reviewed journals.
- 6) Develop accurate fact sheets for the dwarf wedge mussel.
- 7) Resurvey Neversink and Delaware Rivers to assess impacts from severe floodign in 2005 and 2006 and establish new baselines for future comparison.
- 2) Complete ongoing state-wide population surveys in North Carolina and Virginia, assess population status in these states.
- 1) Complete populaion genetic analyses, determine correct taxonomic nomenclature.

- See recovery measures

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Recommendation: Revise recovery plan. New information has become available since the Recovery Plan was written in 1993, both in terms of the species' biology and the status of individual populations (USFWS 2007, 2014). Given the lack of clarity of current recovery criteria, we recommend revising the recovery plan. As part of that process, we recommend using the Species Status Assessment (SSA) framework. Recommendations for specific recovery actions: ▯ Priority 1 - Resolve the question of whether or not northern and southern populations are genetically distinct. ▯ Priority 1 - Develop habitat protection strategies for high priority populations. ▯ Priority 2 - Complete statewide population surveys in NY, NJ, MA, NC, and VA, and assess population status in these states. ▯ Priority 2 - Resurvey the Neversink River (NY), Delaware River (NY/NJ), and Flat Brook (NJ) to assess impacts from severe flooding in 2012 and establish new baselines for future comparison. ▯ Priority 2 - Revisit established survey sites on the Connecticut River that have not been resurveyed within the last 10 years to verify that the subpopulations still persist, as well as to determine the long-term viability of the macrosites (Nedeau, 2009, unpublished). ▯ Priority 2 - Support and assess ongoing methods for captive propagation efforts and subsequent augmentation/reintroduction efforts. ▯ Priority 3 - Develop new rangewide database and maps with partners. Use maps to update IPaC and assist with targeted project reviews and surveys. ▯ Priority 3 - Develop persistence probability models to help determine when a population is healthy and when it may need intervention. To create these models and to ensure that they are realistic and reliable, more data are required. Additional studies that address age structure, sex ratio, age specific growth rate and death rate, and age specific reproduction and survival rates of DWM populations are needed to fill data gaps. ▯ Priority 3 - Develop standardized survey protocols to be used across the range. (USFWS, 2019)
- Conservation Activities Measures have been taken to help address habitat degradation and other potential threats. o In NC, since the last review, the Tar River Land Conservancy acquired 300 acres of land that contain stream habitat for important aquatic resources, including the DWM (S. McRae, USFWS, pers. comm.). o A Programmatic Bridge/Culvert Replacement Biological Opinion (June 13, 2018) included conservation measures as a result of a section 7 consultation that included contribution of funds by the North Carolina Department of Transportation for subsequent use for targeted species surveys/monitoring, relocations, propagation, research, and habitat protection. In addition, the North Carolina Nongame Aquatic Species Fund was created by NCWRC to facilitate voluntary contribution of funds to be used for propagation, surveys, research, and habitat protection (S. McRae, USFWS, pers. comm.). o The Delaware River Dwarf Wedgemussel Technical Committee (Committee), led by the USFWS, is made up of partners from the National Park Service, USGS, Delaware River Basin Commission, Pennsylvania Fish and Boat Commission, and U.S. Army Corps of Engineers (Philadelphia District). The Committee addresses issues that potentially affect the DWM and its habitat in the Delaware River, and provides funding for research, surveys, population estimates, fish host assessments, water quality impacts, and ecological flow needs. o The Delaware River Conservation Act was passed by Congress on December 10, 2016. Priorities include conserving and restoring fish and wildlife habitat, improving and sustaining water quality, upgrading water management, reducing flood damage, and enhancing recreational opportunities and public access. The funds are provided through the National Fish and Wildlife Foundation (NFWF) for projects that conserve and restore fish and wildlife habitat and improve water quality in the Delaware River watershed. In 2019, NFWF's Delaware River Program will award grants through two distinct grant opportunities: the Delaware Watershed Conservation Fund Conservation Action Grants and the Delaware River Restoration Fund Targeted Implementation and Cornerstone Grants. This funding

opportunity can help partners with DWM recovery efforts in the Delaware River. (USFWS, 2019)

References

five year review

final listing rule

USFWS. 2019. Dwarf Wedgemussel Alasmidonta heterodon 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service New York Field Office Cortland, NY. 47 pp.

SPECIES ACCOUNT: *Alasmidonta raveneliana* (Appalachian elktoe)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Appalachian elktoe (Alasmidonta raveneliana) (Lea, 1834) is a freshwater mussel with a thin, but not fragile, kidney-shaped shell, reaching up to about 3.2 inches in length, 1.4 inches in height, and 1 inch in width (Clarke 1981). Juveniles generally have a yellowish-brown periostracum (outer shell surface) while the periostracum of the adults is usually dark brown in color. Although rays are prominent on some shells, particularly in the posterior portion of the shell, mapy individuals have only obscure greenish rays. The shell nacre (inside shell surface) is shiny, often white to bluish-white, changing to a salmon, pinkish, or brownish color in the central and beak cavity portions of the shell; some specimens may be marked with irregular brownish blotches (adapted from Clarke 1981).

Historical Range

fairly widely distributed in western North Carolina

Current Range

North Carolina and Tennessee

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 9/27/2002.

Legal Description

On September 27, 2002, the Fish and Wildlife Service (Service) designated critical habitat for the Appalachian elktoe (Alasmidonta raveneliana) under the Endangered Species Act of 1973, as amended (67 FR 61016 - 61040). The areas designated as critical habitat for the Appalachian elktoe total approximately 231.1 kilometers (144.3 miles) of various segments of rivers in North Carolina and one river in Tennessee.

Critical Habitat Designation

The lateral extent of designated critical habitat within units 1 to 6 is the ordinary high water line on each bank. As defined in 33 CFR 329.11, the ordinary high water line on non-tidal rivers is the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas.

Unit 1. Macon County and Swain County, NC. Unit 1 encompasses approximately 38.5 km (24 mi) of the main stem of the Little Tennessee River, from the Lake Emory Dam at Franklin, Macon County, NC, downstream to the backwaters of Fontana Reservoir in Swain County, NC. This unit is part of the currently occupied range of the Appalachian elktoe and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area supports one of the only three known surviving populations of the Appalachian elktoe in the Little Tennessee River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Appalachian elktoe (Service 1996), protection of this unit is essential to the conservation of the species.

Unit 2. Jackson County and Swain County, NC. Unit 2 encompasses approximately 41.6 km (26 mi) of the main stem of the Tuckasegee River (Little Tennessee River system), from the N.C. State Route 1002 Bridge in Cullowhee, Jackson County, NC, downstream to the N.C. Highway 19 Bridge, north of Bryson City, Swain County, NC. This unit is part of the currently occupied range of the Appalachian elktoe and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area supports one of the only three known surviving populations of the Appalachian elktoe in the Little Tennessee River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Appalachian elktoe (Service 1996), protection of this unit is essential to the conservation of the species.

Unit 3. Graham County, NC. Unit 3 encompasses approximately 14.6 km (9.1 mi) of the main stem of the Cheoah River (Little Tennessee River system), from the Santeetlah Dam, downstream to its confluence with the Little Tennessee River. This unit is part of the currently occupied range of the Appalachian elktoe and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area supports one of the only three known surviving populations of the Appalachian elktoe in the Little Tennessee River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Appalachian elktoe (Service 1996), protection of this unit is essential to the conservation of the species.

Unit 4. Transylvania County, NC. Unit 4 encompasses approximately 7.5 km (4.7 mi) of the main stem of the Little River (French Broad River system), from the Cascade Lake Power Plant, downstream to its confluence with the French Broad River. This unit is part of the currently occupied range of the Appalachian elktoe and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area supports one of the only two known surviving populations of the Appalachian elktoe in the French Broad River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Appalachian elktoe (Service 1996), protection of this unit is essential to the conservation of the species.

Unit 5. Haywood County, NC. Unit 5 encompasses approximately 17.8 km (11.1 mi) of the main stem of the West Fork Pigeon River (French Broad River system), from the confluence of the Little East Fork Pigeon River, downstream to the confluence of the East Fork Pigeon River, and the main stem of the Pigeon River, from the confluence of the West Fork Pigeon River and the East Fork Pigeon River, downstream to the N.C. Highway 215 Bridge crossing, south of Canton, NC. This unit is part of the currently occupied range of the Appalachian elktoe and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area supports one of the only two known surviving populations of the Appalachian elktoe in the French Broad River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Appalachian elktoe (Service 1996), protection of this unit is essential to the conservation of the species.

Unit 6. Yancey County and Mitchell County, NC, and Unicoi County, TN. Unit 6 encompasses approximately 5.9 km (3.7 mi) of the main stem of the North Toe River, Yancey and Mitchell Counties, NC, from the confluence of Big Crabtree Creek, downstream to the confluence of the South Toe River; approximately 22.6 km (14.1 mi) of the main stem of the South Toe River, Yancey County, NC, from the N.C. State Route 1152 Bridge, downstream to its confluence with the North Toe River; approximately 34.6 km (21.6 mi) of the main stem of the Toe River, Yancey and Mitchell Counties, NC, from the confluence of the North Toe River and the South Toe River, downstream to the confluence of the Cane River; approximately 26.4 km (16.5 mi) of the main stem of the Cane River, Yancey County, NC, from the N.C. State Route 1381 Bridge, downstream to its confluence with the Toe River; and approximately 21.6 km (13.5 mi) of the main stem of the Nolichucky River from the confluence of the Toe River and the Cane River in Yancey County and Mitchell County, NC, downstream to the U.S. Highway 23/19W Bridge southwest of Erwin, Unicoi County, TN. This unit is part of the currently occupied range of the Appalachian elktoe and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area supports the only two known surviving populations of the Appalachian elktoe in the Nolichucky River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Appalachian elktoe (Service 1996), protection of this unit is essential to the conservation of the species.

Primary Constituent Elements/Physical or Biological Features

Within the critical habitat untis, the primary constituent elements include:

(i) Permanent, flowing, cool, clean water;

(ii) Geomorphically stable stream channels and banks;

(iii) Pool, riffle, and run sequences within the channel;

(iv) Stable sand, gravel, cobble, boulder, and bedrock substrates with no more than low amounts of fine sediment;

(v) Moderate to high stream gradient;

(vi) Periodic natural flooding; and

(vii) Fish hosts, with adequate living, foraging, and spawning areas for them.

Special Management Considerations or Protections

The areas in the six units that designated as critical habitat for the species include habitat for each of these populations. All of the areas we are designating as critical habitat are within what we believe to be the geographical area occupied by the Appalachian elktoe, include all known surviving occurrences of the species, are essential for the conservation of the species, and provide for the species' essential life cycle needs. All of the designated areas require special management considerations to ensure their contribution to the conservation of the Appalachian elktoe.

Life History

Feeding Narrative

Larvae: Glochidia depend on a host to feed from. Glochidia host species include the banded sculpin (Cottus carolinae) and the mottled sculpin (C. bairdi). Eight additional fish species have successfully transformed glochidia of Appalachian elktoes into juveniles under laboratory condition.

Juvenile: Juveniles use pedal feeding to consume bacteria, detritus, diatoms, phytoplankton, and zooplankton.

Adult: Like other freshwater mussels. the Appalachian elktoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924).

Reproduction Narrative

Adult: The reproductive cycle of the Appalachian elktoe is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they then parasitize for a short time while they develop into juvenile mussels. They then detach from their “fish host” and sink to the stream bottom where they continue to develop, provided they land in asuitable substrate with the correct water conditions. Studies have identified the banded sculpin (Cottus carolinae) as a host species for glochidia of the Appalachian elktoe.

Geographic or Habitat Restraints or Barriers

Larvae: dams

Juvenile: dams

Adult: dams

Spatial Arrangements of the Population

Larvae: Clumped on fish gills

Juvenile: Clumped according to suitable habitat characteristics

Adult: Clumped according to suitable habitat characteristics

Environmental Specificity

Larvae: Narrow. Specialist or community with key requirements common.

Juvenile: Narrow. Specialist or community with key requirements common.

Adult: Narrow. Specialist or community with key requirements common.

Tolerance Ranges/Thresholds

Larvae: Sensitive to pollution

Juvenile: Sensitive to pollution

Adult: Sensitive to pollution

Site Fidelity

Larvae: Dependent on host

Juvenile: High

Adult: High

Dependency on Other Individuals or Species for Habitat

Larvae: banded sculpin (Cottus carolinae); mottled sculpin (C. bairdi); possibly several other fish species

Juvenile: Not applicable

Adult: Not applicable

Habitat Narrative

Adult: The Appalachian elktoe has been reported from relatively shallow, medium-sized creeks and rivers with cool, clean, well-oxygenated, moderate- to fast-flowing water. The species is most often found in riffles, runs, and shallow flowing pools with stable, relatively silt-free, coarse sand and gravel substrate associated with cobble, boulders, and/or bedrock (Gordon 1991; Service 1994, 1996, 2002; J. Alderman, formerly with NCWRC, pers. comm., 2000; McGrath pers. comm., 2000; Savidge pers. comm., 2000; Fridell pers. observ., 1989 through 2004). Stability of the substrate appears to be critical to the Appalachian elktoe, and the species is seldom found in stream reaches with accumulations of silt or shifting sand, gravel, or cobble (Fridell, pers. observ. 1989 through 2001; Fraley andSimmons 2006). Individual specimens that have been encountered in these areas are believed to have been scoured out of upstream areas during periods of heavyrain and have not been found during subsequent surveys (McGrath pers. comm. 1996; Fridell pers. observ. 1995, 1996, 1999). Suitable habitat in the majority of streams where the species survives is limited – the majority of the surviving populations are comprised of scattered occurrences of the species, restricted to pockets or short reaches of suitable habitat. Large reaches of many of the streams supporting the species have been degraded by past and/or on-going land disturbance activities and alterations to natural flow and temperature regimes. In many instances, habitat for the mussels has been degraded and is marginal or unsuitable. Although there have been noticeable improvements in habitat quality in recent years in some areas supporting the species, particularly in portions of the Nolichucky River system, most of the watersheds of the rivers supporting the Appalachian elktoe are experiencing or are threatened with a significant increase in residential and industrial development. Without adequate regulations or other forms of protection in place, habitat and water quality in many of these rivers is expected to decline.

Dispersal/Migration

Motility/Mobility

Larvae: Yes; via host

Juvenile: No

Adult: No

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Dispersed via host

Juvenile: Non-migratory

Adult: Non-migratory

Dispersal

Larvae: Yes

Juvenile: No; unless strong flow pushes them downstream

Adult: No; unless strong flow pushes them downstream

Immigration/Emigration

Larvae: No

Juvenile: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Larvae: banded sculpin (Cottus carolinae); mottled sculpin (C. bairdi); possibly several other fish species

Juvenile: Not applicable

Adult: Not applicable

Dispersal/Migration Narrative

Adult: The currently known populations of the Appalachian elktoe are only remnants within this species' historical range and exist as fragmented and, for the most part, separate entities (there is a potential that there may be some genetic interchange between the Little River and Mills River populations and the between the Little Tennessee River and Tuckasegee River populations but genetic studies are needed to confirm this). All of the surviving populations are separated from one anotherby major impoundments and/or apparently unsuitable habitat. This species is probably mostly sessile with only limited movement through the substrate. Passive downstream displacement may occur when mussels are dislodged from the substrate during flooding events. Major dispersal occurs while the glochidia are on their hosts.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
unknown

Number of Populations:
8 (USFWS, 2022)

Population Size:
unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
Low

Population Narrative:
Long-term viability of the small number of extant populations is compromised by potential continuing declines. The almost all the surviving occurrences of Appalachian elktoe appear to be small (most with poor viability) and restricted to scattered pockets of suitable habitat. The few remaining populations are threatened by siltation and a proposed, privately-owned hydroelectric dam which would flood most, if not all, of the remaining habitat of one of the populations. Severe decline (>70%) in numbers and loss or population occurrences has occurred across its former range and threats (pollution, habitat loss) persist and continue to threaten existing populations.

Threats and Stressors

Stressor: Habitat degradation
Exposure:
Response:
Consequence:
Narrative: Habitat and water quality degradation alteration resulting from impoundments; stream channelization; dredging; industrial and sewage effluent; and the runoff of silt and other pollutants from poorly implemented mining, constructionidevelopment, agricultural, and past

logging activities are believed to be the primary factors resulting in the elimination of the species from the majority of its historic range.

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Land-clearing/disturbance activities carried out without proper sedimentation control pose a significant threat to freshwater mussels. Mussels are sedentary and are not able to move long distances to more suitable areas in response to heavy silt loads. Natural sedimentation resulting from seasonal storm events probably does not significantly affect mussels, but human activities often create excessively heavy silt loads that can have severe effects on mussels and other aquatic organisms. Siltation hasbeen documented to adversely affect native freshwater mussels both directly and indirectly. Siltation degrades water and substrata quality, limiting the available habitat for freshwater mussels (and their fish hosts), thereby limiting their distribution and potential for expansion and maintenance oftheir populations. It also irritates and clogs the gills of filter-feeding mussels, resulting in reduced feeding and respiration, and smothers mussels if sufficient accumulation occurs. Siltation increases the potential exposure ofthe mussels to other pollutants (Ellis 1936, Marking and Bills 1979, Kat 1982). Ellis (1936) found that less than 1 inch ofsediment deposition caused high mortality in most mussel species. Sediment accumulations that are less than lethal to adults may adversely affect orprevent recruitment of juvenile mussels into the population. Also, sediment loading in rivers and streams during periods ofhigh discharge is abrasive to mussel shells. Erosion of the outer shell allows acids to reach and corrode underlying layers (Harman 1974).

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Mussels are also known to be sensitive to numerous other pollutants, including, but not limited to, a wide variety ofheavy metals, high concentrations ofnutrients, and chlorine--pollutants that are commonly found in many domestic and industrial effluents (Havlik and Marking 1987). In the early 1 900s Ortmann (1909) noted that the disappearance ofunionids (mussels) is the first and most reliable indicator ofstream pollution. Keller and Zam(1991) concluded that mussels are more sensitive to metals than commonly tested fish and aquatic insects. The life cycle of native mussels makes the reproductive stages especially vulnerable to pesticides and other pollutants (Ingram 1957, Stein 1971, Fuller 1974, Gardner et al. 1976). Effluent from sewage treatment facilities can be a significant source ofpollution that can severely affect the diversity and abundance ofaquatic mollusks. The toxicity ofchlorinated sewage effluents to aquatic life

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The effects ofimpoundments on mussels are also well documented. The closure of dams changes the habitat from a lotic to a lentic condition. Depth increases, flow decreases, and silt accumulates on the bottom. Hypolimnetic discharge lowers water temperatures downstream.

Fish communities change, and host fish species may be eliminated. Mussel communities change; species requiring clean gravel and sand substrate are lost (Bates 1962). In addition, the construction ofdams results in the fragmentation and isolation ofthe species' populations, and these dams act as effective barriers to natural upstream expansion orrecruitment ofmussel and fish species.

Stressor: Invasive species
Exposure:
Response:
Consequence:
Narrative: Another potential threat to the Appalachian elktoe is the introduction and/or invasion of exotic species. For example, the Asiatic clam, Corbiculafluminea, one of204 introduced mollusk species in North America (Dundee 1969), was first discovered in the United States in the Columbia River in Oregon in 1939. By 1972 the species could be found in most ofthe major river systems throughout the United States (Fuller and Powell 1973). While C. fluminea has not been observed in the stretch ofthe Little Tennessee River still inhabited by the Appalachian elktoe, it has become well established in portions of the Toe and Nolichucky Rivers. The extent ofthe threat that C. fluminea presents to the elktoe and other native mussel populations is presently unknown and requires further study. Many malacologists are concerned about the possibility of a competitive interaction for space, oxygen, and food between C. fluminea and native bivalves. Competition may not occur among adults but, rather, at the juvenile stage (Neves and Widlak 1987). Because of its restricted distribution, the Appalachian elktoe may not be able to withstand vigorous competition.

Stressor: Predation
Exposure:
Response:
Consequence:
Narrative: Predation may also pose a threat to the continued existence of the Appalachian elktoe. Shells of the Appalachian elktoe are often found in muskrat middens along the reach ofthe Little Tennessee River where the species still exists and occasionally in middens along the Nolichucky River. The species also is presumably consumed by other mammals, such as racoon and mink. While predation is not thought to be a significant threat to a healthy mussel population, it could, as suggested by Neves and Odum (1989), limit the recovery ofendangered mussel species or contribute to the local extirpation of mussel populations already depleted by other factors.

Recovery

Reclassification Criteria:
1. Through protection of existing populations and successful establishment of reintroduced populations or the discovery of additional populations, a total of four distinct viable populations exist. (A viable population is defined as a naturally reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural environmental changes.) These four populations shall be distributed throughout the species' historic range, with at least one each in the Little Tennessee, French Broad, or Nolichucky River systems. Also, these populations must be extensive enough that it is unlikely that a single event would not eliminate or significantly reduce one or more of these populations. 2. Three distinct

naturally reproduced year classes exist within each of the four populations. One of these year classes must have been produced within the 3 years prior to the time the species is reclassified from endangered to threatened. Within the year prior to the downlisting date, gravid females and the mussel's host fish must be present in each populated river/stream reach. 3. Biological and ecological studies have been completed and any required recovery measures developed and implemented from these studies are beginning to show signs of success, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the four populations. 4. Where habitat has been degraded, noticeable improvements in water and stratum quality have occurred. 5. Each of these four populations and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence. 6. All four populations remain stable or increase over a period of 10 to 15 years.

Recovery Priority Number: 5C

Delisting Criteria:
1) Through protection ofboth existing populations and successful establishment or discovery of additional populations, a total of six distinct viable populations exist within the species' historic range, with at least one each in the Little Tennessee, French Broad, and Nolichucky River systems; (2) each ofthe six populations have at least three year classes present and show evidence ofreproduction, including gravid females, and at least one juvenile age class (age 3 oryounger); (3) all six populations and their habitats are protected from present and foreseeable threats; and, (4) all six populations remain stable or increase over a period of 10 to 15 years.

Recovery Actions:
- 1. Improve planning, coordination, and efficacy of recovery activities with key partners (e.g., NCWRC, NCDWQ, NRCS, TVA, local governments, local conservation NGOs, researchers, etc.) by meeting at least annually to share information and review and recommend priority recovery actions.
- 2. Continue working with state and local governments to implement protective regulations/ordinances for addressing the impacts and threats from development and other land disturbance activities. One of the highest priorities is to continue to work closely with NCDWQ and other state and local partners to develop, encourage public support for, and effectively implement site specific water quality management strategies to protect listed species in the Little Tennessee and French Broad river basins as required by North Carolina Procedures for Assignment of Water Quality Standards Rule 15A NCAC 02B .0110.
- 3. Formalize a detailed population and habitat monitoring plan for all surviving populations.
- 4. Continue analyzing threats to the species and measures for off-setting these threats; conduct studies to determine the extent and cause of the recent decline of the Little Tennessee River population and measures necessary for stabilizing and recovering this population; determine species specific vulnerability to commonly discharged wastes (e.g. ammonia, chlorine) for which present discharge limits may not be protective of mussels.
- 5. Fund or seek funding for analysis of existing samples to determine intra- and interpopulation genetics. This information is necessary to estimate the relative viability of populations, to provide guidance for augmentation and reintroduction efforts, and inform other potential management actions.
- 6. Continue habitat, life history, and captive propagation studies aimed at specific conservation applications, including: water temperature tolerances and optimal range;

instream flow requirements and specific impacts from altered flow regimes; support continued controlled propagation experiments with congeneric surrogates and permit work directly with Appalachian elktoe.

- 7. Develop a population augmentation plan for the Cheoah River population and evaluate necessity for augmentation of other populations.
- 8. Continue working with partners to establish conservation easements and restore forested buffers and instream habitat.
- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Continue analyzing threats to the specie and measures for offsetting these threats 2. Fund or seek funding to continue the genetic analysis of existing populations. 3. Continue habitat. life history, and captive propagation studies. 4. Develop a population augmentation/reintroduction plan for each of the occupied watersheds. 5. Continue working with partners to establish conservation easements and restore forested buffers and in-stream habitat (USFWS, 2017).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES Continued assessment of the health of the remaining populations is critical to further recovery planning. • The Tuckaseegee River population is a crucial component of the greater Little Tennessee River population, and it is important to take proactive measures to ensure this population is actively managed so that it remains viable. This may require additional efforts to establish the Appalachian elktoe in the Oconaluftee River in cooperation with the Eastern Band of Cherokee Indians. • The upper portion of the South Toe River supports the last robust sub-population in the Nolichucky River System. This population should be used to re-populate the Cane River and the upper North Toe portions of this greater population so the species is better protected from potential threats to the South Toe River. • In the Pigeon River, the West Fork Pigeon supports a much greater number of Appalachian elktoe than the East Fork Pigeon River. It would benefit the Pigeon River population to establish a study plot of Appalachian elktoe in the East Fork Pigeon River to investigate its potential to support additional Appalachian elktoe so the species is better protected from threats only affecting one of the forks.   In the French Broad River, the population in the Little River is crucial to the long-term stability of this greater population, but the Little River is heavily influenced by the presence of Cascade Lake Dam. Efforts should be made to use the Little River population as a source population for establishing better demographics in the French Broad River mainstem, Mills River and possibly additional populations in other tributaries of the French Broad River while Cascade Lake Dam continues to protect water quality in the reaches downstream. Efforts should be made to assess options to continue protecting water quality in the Little River in the future, e.g., protecting riparian zones upstream and in areas where Appalachian elktoe occur and decreasing point source and non-point source population. • If possible, agreements should be made with the State of North Carolina and other partners entities so that re-establishment of Appalachian elktoe throughout its historical range is more readily accomplished. • Continued cooperation with the NCWRC Conservation Aquaculture Center (CAC) in Marion, NC, is crucial to the recovery of the species. The CAC has been instrumental in research on the life history of Appalachian elktoe and have been a primary partner in developing the technology necessary to manage the species. Future recovery activities will rely heavily on the CAC for support (USFWS, 2022).

References

NatureServe

Final Listing Rule

5 year review

Final critical habitat rule

U.S. Fish and Wildlife Service. 2002. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Appalachian Elktoe. Final rule. 67 FR 61016 - 61040 (September 27, 2002).

NatureServe, 5 year review, Final Listing Rule. USFWS. 2022. Appalachian Elktoe (Alasmidonta ravaneliana) Status Review: Summary and Evaluation. Southeast Region. Asheville North Carolina Ecological Services Field Office Asheville, North Carolina. 18 pp.

NatureServe, 5 year review, Final Listing Rule

Recovery plan

five year review

USFWS. 2017. 5-Year Review Summary and Evaluation. Appalachian elktoe. Alasmidonta raveneliana. U.S. Fish and Wildlife Service. Southeast Region. Asheville Ecological Services Field Office. Asheville, North Carolina.

USFWS. 2022. Appalachian Elktoe (Alasmidonta ravaneliana) Status Review: Summary and Evaluation. Southeast Region. Asheville North Carolina Ecological Services Field Office Asheville, North Carolina. 18 pp.

SPECIES ACCOUNT: *Alasmidonta triangulata* (Southern elktoe)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

The Southern Elktoe is medium-sized mussel reaching up to 70 millimeters (mm) (2.8 inches (in)) in length. The shell is moderately thin and somewhat triangular in shape. Adults are olive brown to black in color, and usually with obscured rays; juveniles are typically yellowish brown to olive, and often with dark green rays. The Southern Elktoe is distinguished by its moderately to highly inflated shell, sharp posterior ridge, and umbo which is elevated well above the hinge line (USFWS, 2022).

Taxonomy

The Southern Elktoe (Alasmidonta triangulata; Lea 1858) belongs to the family Unionidae, a large group of freshwater mussels represented by more than 290 species in North America (Williams et al. 2017, p. 45). The genus Alasmidonta currently contains 12 species with three presumed extinct (Williams et al. 2017, p. 36). Originally described as Margaritana triangulata by Isaac Lea in 1858, Alasmidonta triangulata has been treated as a synonym of Alasmidonta undulata by Clarke (1981, pp. 38-48) and Williams and Butler (1994, pp. 56-58). Alasmidonta triangulata was recognized as a valid species by Johnson (1970, pp. 351-352, 430-431), but he gave its distribution as Apalachicola River basin and southern Atlantic Coast rivers in Georgia and South Carolina. Specimens of Alasmidonta arcula from Savannah and Ogeechee Rivers are conchologically similar to A. triangulata, however, Frierson (1927, p. 18), Clench and Turner (1956, pp. 180-181), Heard (1979, p. 28), Brim Box and Williams (2000, pp. 28-29), Williams et al. (2008, pp. 120-122), Williams et al. (2011, p. 71), Williams et al. (2014, pp. 132-134), and Williams et al. (2017, p. 36) all support Southern Elktoe as a valid species endemic to the Apalachicola River basin in Alabama, Florida, and Georgia (USFWS, 2022).

Historical Range

Based on what we know of the historical range of Southern Elktoe, it occurred in a range of habitat conditions from small streams to large rivers. Species with an ability to persist in a variety of habitats theoretically represent a greater ability to adapt to environmental change than species with a narrow habitat tolerance. To evaluate patterns in the types of lotic habitats in which Southern Elktoe has been documented, we use the classification system presented in McManamay et al. (2018, entire). The 36 sub-watersheds in which Southern Elktoe historically occurred ranged from Creek to Great River, but since 2000 the species has not been observed in the Creek sub-watersheds (Maringo Creek, Uchee Creek Watershed), or eight of the ten small river sub-watersheds. If we further subdivide the current time period (2000-2019) into more recent years that would be within the life span of Southern Elktoe, there have been no observations in the small river habitats, and only one of the initial six medium river subwatersheds. Since 2010, Southern Elktoe has only been observed in 8 of the 35 known historical sub-watersheds, and has only been observed in habitats from medium to great rivers (USFWS, 2022).

Current Range

Based on our analysis of the three Rs in this section, Southern Elktoe exhibits low population resilience throughout most of its range, and habitat stressors are present with most populations (Figure 4.2). There is low or no resilience among all six populations (Figure 4.2), which has resulted in concurrent losses in redundancy and representation. The Middle Chattahoochee population characteristics indicate it is not resilient, and both agricultural and urban land uses in watersheds of the population are presumed to negatively impact water quality and quantity. The Upper Flint River population is also categorized as not resilient, with primarily urban influences in the upper extent of the watershed. Southern Elktoe may be extirpated from these smaller stream and river habitats; contemporary sampling in these areas is needed. In the Ichawaynochaway and Lower Flint River populations, some population metrics from recent collections indicate increased resilience over the previous two populations, but they are still characterized as having poor or no resilience overall, and agricultural land uses are highest in watersheds of these populations. Stressors to Southern Elktoe habitat from agricultural and urban land uses are present in all populations except the Apalachicola River. No populations are characterized as exhibiting characteristics of moderate or high resilience at this time, and there have been no collections in the northern extent of the species' range since 2007, which is a loss of longitudinal representation and habitat diversity representation. Southern Elktoe is currently restricted to larger rivers and mainstem habitats in the southern extent of the ACF Basin, which represents significantly reduced representation and redundancy from historical conditions (USFWS, 2022).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Food/Nutrient Narrative

Larvae: The glochidia of Southern Elktoe, like most freshwater mussels, are obligate parasites on fish and must attach to a fish host in order to transform into juvenile mussels (Figure 2.3). A reproductive study found that Southern Elktoe, like other Alasmidonta species (A. arcula, Johnson et al. 2012, p. 739), use species from the sucker family (Catostomidae) as primary glochidial hosts (Fobian et al. 2018 p. 9). Southern Elktoe glochidia primarily metamorphosed on Apalachicola Redhorse (Moxostoma sp. cf. poecilurum), Greater Jumprock (M. lachneri), Creek Chubsucker (Erimyzon oblongus), and Lake Chubsucker (E. sucetta). In addition, Blacktail Redhorse (M. poecilurum) from the Cahaba River Basin exhibited high metamorphosis success. Five species exhibited marginal success (four Catostomids and one Cyprinid). In all, successful metamorphosis of glochidia was observed on 10 of 27 species tested and 2 of 9 families (USFWS, 2022).

Adult: Adult freshwater mussels are suspension-feeders and filter particles from the water column. Mussels may also obtain food by deposit feed using cilia on their foot to move food particles into the shell (Haag 2012, pp. 27–28), though reasons for this are poorly known and may depend on flow conditions or temperature. For their first several months, juvenile mussels ingest food through their foot and are thus deposit feeders, although they may also filter interstitial pore water and soft sediments (Yeager et al. 1994, p. 221; Haag 2012, p. 26-27). Mussel diets consist of a mixture of algae, bacteria, detritus, and microscopic animals (Gatenby et al. 1996, p. 606; Strayer et al. 2004, p. 430). It has also been surmised that dissolved organic matter may be significant source of nutrition (Strayer et al. 2004, p. 431). Such an array of foods, containing essential long-chain fatty acids, sterols, amino acids, and other biochemical compounds, may be necessary to supply total nutritional needs (Strayer et al. 2004, p. 431). Food availability and quality are affected by habitat stability, floodplain connectivity, flow, and water quality. Food availability may also be affected by the presence of moderate to high densities of Asian Clams (Corbicula fluminea), which can remove a substantial amount of suspended material from the water column (USFWS, 2022).

Reproductive Strategy

Adult: Broadcast spawning

Lifespan

Adult: 15-40 years (estimated). Some freshwater mussels are long–lived and slow–growing, while others grow quickly and have short life spans. Life span varies widely by mussel species, but most species fall between 15–40 years (Haag 2012, p. 181). Generally, thin–shelled species grow faster and have shorter life spans, while heavy–shelled species grow slowly and tend to reach higher maximum ages. Little is known about growth or longevity of Southern Elktoe. Thus, we rely on information for closely related species to help summarize characteristics of this species. Species in the tribe Andontini, which includes the Southern Elktoe, generally share the following traits: moderate to high growth rate, moderate life span, early maturity, and low to moderate fecundity (Haag and Rypel 2011, p. 239; Haag 2012, pp. 210-214). More specifically, three species of Alasmidonta reached maximum ages of 10–18 years and matured at 2–3 years (Haag 2012, p. 423). Given uncertainty in the true maximum age range of Southern Elktoe, in later current and future condition analyses we consider 10 years the presumed lifespan, and age-3 the presumed age at maturity. It is important to note possible impacts of this uncertainty to population dynamics (ie, an individual mature at age-2 that survives until age-18 can contribute more to future generations than an individual that matures at age-3 and survives to age-10). To define a size range for juvenile Southern Elktoe in this SSA report, we use the shell length <25 mm as used in evaluating freshwater mussels of the Flint River (Wisniewski et al. 2014, p. 35, based on previous work by Haag and Warren 2007 and Negishi and Kayaba 2010). (USFWS, 2022).

Key Resources Needed for Breeding

Adult: Host fish. Southern Elktoe glochidia primarily metamorphosed on Apalachicola Redhorse (Moxostoma sp. cf. poecilurum), Greater Jumprock (M. lachneri), Creek Chubsucker (Erimyzon oblongus), and Lake Chubsucker (E. sucetta). In addition, Blacktail Redhorse (M. poecilurum) from the Cahaba River Basin exhibited high metamorphosis success. Five species exhibited marginal success (four Catostomids and one Cyprinid). In all, successful metamorphosis of glochidia was observed on 10 of 27 species tested and 2 of 9 families (USFWS, 2022)

Other Reproductive Information

Adult: The glochidia of Southern Elktoe, like most freshwater mussels, are obligate parasites on fish and must attach to a fish host in order to transform into juvenile mussels (Figure 2.3). A reproductive study found that Southern Elktoe, like other Alasmidonta species (A. arcula, Johnson et al. 2012, p. 739), use species from the sucker family (Catostomidae) as primary glochidial hosts (Fobian et al. 2018 p. 9). Southern Elktoe glochidia primarily metamorphosed on Apalachicola Redhorse (Moxostoma sp. cf. poecilurum), Greater Jumprock (M. lachneri), Creek

Chubsucker (Erimyzon oblongus), and Lake Chubsucker (E. sucetta). In addition, Blacktail Redhorse (M. poecilurum) from the Cahaba River Basin exhibited high metamorphosis success. Five species exhibited marginal success (four Catostomids and one Cyprinid). In all, successful metamorphosis of glochidia was observed on 10 of 27 species tested and 2 of 9 families (USFWS, 2022).

Reproduction Narrative

Larvae: The glochidia of Southern Elktoe, like most freshwater mussels, are obligate parasites on fish and must attach to a fish host in order to transform into juvenile mussels (Figure 2.3). A reproductive study found that Southern Elktoe, like other Alasmidonta species (A. arcula, Johnson et al. 2012, p. 739), use species from the sucker family (Catostomidae) as primary glochidial hosts (Fobian et al. 2018 p. 9). Southern Elktoe glochidia primarily metamorphosed on Apalachicola Redhorse (Moxostoma sp. cf. poecilurum), Greater Jumprock (M. lachneri), Creek Chubsucker (Erimyzon oblongus), and Lake Chubsucker (E. sucetta). In addition, Blacktail Redhorse (M. poecilurum) from the Cahaba River Basin exhibited high metamorphosis success. Five species exhibited marginal success (four Catostomids and one Cyprinid). In all, successful metamorphosis of glochidia was observed on 10 of 27 species tested and 2 of 9 families

Adult: Freshwater mussels have a complex, multi-staged life cycle (Figure 2.3). Reproduction begins with males releasing sperm into the water column, which is taken in by the female through the incurrent aperture. The sperm fertilizes eggs that are held within the female's gills in the marsupial chamber. The developing larvae (called glochidia) remain in the gill chamber until they mature and are ready for release. Brooding females have been observed from mid-October to February in the Flint River for Southern Elktoe and in the Altamaha River for congener A. arcula (USFWS, 2022).

Habitat Type

Adult: Creeks/Rivers (USFWS, 2022)

Dependencies on Specific Environmental Elements

Adult: dependent upon areas with low shear stress and where stream bottom sediments remain stable during high flow events (USFWS, 2022).

Geographic or Habitat Restraints or Barriers

Adult: Dams (USFWS, 2022)

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: High

Habitat Narrative

Adult: Because freshwater mussels are relatively long-lived and have limited mobility, habitat stability is a requirement shared by nearly all unionids (Haag 2012, p. 106). Optimal substrate for the Southern Elktoe is stable sand, silt, and gravel without excessive accumulation unconsolidated sand, silt, or detritus. These substrates are dependent on stable stream channels and intact riparian areas (Allan et al. 1997, p. 149). The Southern Elktoe, similar to other mussels, is dependent upon areas with low shear stress and where stream bottom sediments remain stable during high flow events (Hastie et al. 2001, pp. 111–114; Gangloff and Feminella 2007, p. 71; Strayer 2008, pp. 48-51). Stable stream channels are formed and maintained by natural flow regimes, channel features (dimension, pattern, and profile), and natural sediment input to the system through periodic flooding, which maintains connectivity and interaction with the floodplain. Stable stream channels consistently transport their sediment load, such that the stream bed neither degrades nor aggrades (Rosgen 1996, pp. 1–3). Stable stream channels also have lower suspended sediment loads which mussels require in order to efficiently feed, respire, and to reproduce. The effects of high suspended particles is discussed in more detail under Water Quality (Section 2.4.3) below. Channel instability is induced by changes in natural sediment or flow regimes, and by physical modifications to the stream channel or floodplain (USFWS, 2022)

Dispersal/Migration

Dispersal

Adult: High

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish

Dispersal/Migration Narrative

Adult: Parasitism serves as the primary dispersal mechanism for this relatively immobile group of organisms (Haag 2012, p. 145). The intimate relationship between freshwater mussels and their host fish plays a major role in mussel distributions on both a landscape and community scale (USFWS, 2022)

Population Information and Trends

Resiliency:

Based on only the population resilience index, all six populations of Southern Elktoe exhibit limited resilience at this time, with two populations (Middle Chattahoochee and Upper Flint) classified as not resilient, three (Ichawaynochaway, Lower Flint, and Apalachicola) as having poor resilience, and only the Chipola River as having fair resilience (Figure 4.2). However, when combined to the Overall Resilience Index, the presence of land use stressors in the Chipola and Lower Flint sub-basins reduces resilience in those populations each by one category (USFWS, 2022).

Representation:

River Basin: Southern Elktoe was documented present in all four major river basins during 2000-2019 (Chattahoochee, Flint, Apalachicola, and Chipola; see Chapter 3). It was last collected in the Chattahoochee Basin in 2006, in the Flint Basin in 2019, in the Apalachicola in 2018 and the Chipola in 2018. Longitudinal: Longitudinal variation in the ACF Basin occurs along the entirety of the basin, and represents changes that may be important to freshwater mussels including changes in local climate and weather, and changes in geology and hydrology which we represent in this SSA by looking at ecoregions and corresponding aquifers (Figures 4.3 and 4.4). There have not been any documented collections of Southern Elktoe in the Piedmont ecoregion during 2000-2019; only a weathered shell was noted from Potato Creek in 2000, which we considered a historic record rather than current occurrence. In the northern areas of the Southeastern Plains' Sand Hills, Southern Elktoe were collected in both the Flint and Chattahoochee Basins since 2000, although both are prior to 2010. Most collections in the Flint Basin since 2000 are in the Dougherty Plain, which is an area where the Floridan aquifer (Figures 4.3 and 4.4) is accessible and used heavily for irrigation. The Chipola River Basin is fed by numerous groundwater sources and springs are (USFWS, 2022).

Redundancy:

Considering available data for mussel sampling and Southern Elktoe collections in the ACF Basin since 2000, we determined Southern Elktoe currently has limited resilience throughout its range (Figure 4.2). The populations currently characterized as not resilient are in the middle Chattahoochee River the Upper Flint River sub-basins. the two populations categorized as not resilient are in the northern extent of the range Figure 4.2). The only population with fair resilience is the Chipola River population. Populations with poor resilience are in the lower ACF Basin in the Ichawaynochaway, Lower Flint River, Apalachichola River sub-basins. The smaller tributaries present in these two watershed may be more susceptible to scour and desiccation associated with high and low flow events, which are negatively correlated with mussel survival and recruitment. The rivers in the southern extent of the ACF Basin have a higher median discharge which likely allows for a higher potential population growth rate, and may offset the higher extinction probability associated with increased water use (Shea et al. 2013, 389-392). Riverine habitat throughout the ACF Basin is fragmented by numerous barriers, which likely shaped the observed current distribution of the Southern Eltoe among reasonably isolated areas in the Basin. A catastrophic event would likely extirpate the population(s) affected. While it is uncertain what distance or habitat types may prohibit dispersal of Southern Elktoe by Catostomid host fishes, the only populations that potentially could support recolonization by an adjacent population would be Ichawaynochaway/Lower Flint or Chipola/Apalachicola (USFWS, 2022).

Population Narrative:

Taking into considerations some limitations on data for Southern Elktoe as discussed in Section 3.2.1, to understand current and future condition of the species we need to use the data that we do have to try to interpret which populations have evidence of stable or increasing trends and/or which populations may have conditions suitable for reproduction, and then subsequent growth and survival of metamorphosed glochidia into juveniles and then adult mussels. Based on the length cut-off of 25 mm to define a juvenile mussel (see Section 2.3.3), we are not aware of any records of a juvenile Southern Elktoe collected from the ACF Basin. However, this would also likely require dredge sampling and not tactile sampling sampling as small mussels are often more difficult to detect than large mussels. Observation of multiple size classes of individuals can serve as a surrogate for direct observation of juveniles and reproductions. We are uncertain of size-at-age of Southern Elktoe, because they grow rapidly and there is likely considerable overlap of size-at-age once individuals reach ages 2-3. However, we have reasonable certainty that individuals under 50 mm represent younger age classes of Southern Elktoe and therefore that reproduction occurred within the last few years, which is an important characteristic for populations to be considered resilient (USFWS, 2022).

Threats and Stressors

Stressor: Agricultural Activities (USFWS, 2022)

Exposure:
Response:
Consequence:
Narrative: Agricultural activity can influence water quality, channel geomorphology, substrate suitability, and water quantity. While not all agricultural activities result in negative effects to freshwater mussels, the direct and secondary effects are well documented. Water pollutants associated with runoff from agricultural activity may adversely affect mussels. In the ACF Basin, agricultural contaminants include excess nutrients from poultry farms and livestock feedlots, and pesticides and fertilizers from row crop agriculture (Couch et al. 1996, p. 52; Frick et al. 1998, p. 2). Excess nitrogen and phosphorus from fertilizer and animal waste can result in harm to aquatic species through decreased dissolved oxygen levels from algal overgrowth (USEPA 2008, p. 1). Some pesticide components entering streams are highly toxic to juvenile and adult freshwater mussels (Bringolf et al. 2007a, p. 2092). Livestock grazing in riparian buffers can also increase runoff and erosion and alter stream hydrology (Agouridis 2005, p. 593). Light to moderate levels of siltation are common in many Apalachicolan Region streams, particularly in the Piedmont, which is known for its highly erodible soils (Couch et al. 1996, p. 7). The decline of the rich mussel fauna of the Chattahoochee River was attributed in part to erosion from intensive farming before the Civil War (USFWS, 2022).

Stressor: Urbanization (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: One of the primary extinction drivers for endangered species is direct habitat losses and fragmentation from urban development. For Southern Elktoe, however, urbanization is indirectly driving many other water-related factors which are the primary threats currently, and will likely remain so in the future. The Atlanta metro region occupies a relatively small portion of the mussel's range, but has a large ecological footprint and substantial downstream effects as the nexus of water demand in the region. The city holds substantially greater political and economic power than the rural areas to its south, where the vast majority of the Southern Elktoe's range occurs. Atlanta is considered the center of a hypothesized future "megaregion" in the Piedmont-Atlantic region extending from Birmingham, AL, to Raleigh, NC, based on expanding populations in the Southeast (USFWS, 2022).

Stressor: Dams and impoundments (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Habitat fragmentation and degradation of lotic habitats in the time period since widespread dam construction is a primary factor that has contributed to loss of mussel diversity and extinction of species (Haag and Williams 2014, p. 47-48). There are 16 main stem impoundments in the ACF Basin that were constructed between 1834 and 1975 (Brim Box and Williams 2000, p. 4). Iterations of the River and Harbors Act (1874, 1945 and 1946) provided for navigation alterations and the construction of locks, dams, and reservoirs by USACE as part of a general plan to provide system-wide benefits for multiple purposes including navigation, flood control (flood risk management), hydropower generation, water supply, water quality, recreation, and fish and wildlife conservation. The Chattahoochee River mainstem alone has 11 dams, including three locks and dams along its lower half that facilitate navigation from

Columbus, Georgia, downstream. The lowermost mainstem of the Chattahoochee River is permanently inundated for approximately 402 km (250 mi). An additional 80 km (50 mi) of mainstem habitat are impounded upstream of Atlanta, making approximately 482 km (300 mi) of the Chattahoochee's 700 km (435 mi) total length (69 percent) impounded. An additional 177 km (110 mi or 29%) of main stem riverine habitat in the Flint River have been permanently altered by two reservoirs. The Jim Woodruff Dam at the confluence of the Flint and Chattahoochee Rivers affects the Apalachicola River. The lowermost portion of numerous other tributaries are also permanently flooded throughout these reservoirs. Smaller impoundments on other streams (e.g., Dead Lake, Chipola River) may have also been detrimental to mussels (Watters 1996, entire). Although the dam was removed in 1987, Dead Lake continues to be highly sedimented and is limited to silt tolerant species. Impoundments, as barriers to dispersal, contribute to losses of local subpopulations by blocking recolonization (Luttrell et al. 1999, p. 986). When considering barriers of all sizes throughout the range of Southern Elktoe, including tributaries, barriers by population (in decreasing order) total: Upper Flint (1,826), Middle Chattahooche (940), Ichawaynochaway (24), Lower Flint (441), Apalachicola (52), Chipola (36) (data were summarized by watershed where Southern Elktoe were present historically and/or currently, as in Table 3.2; SARP 2020). We are uncertain the extent to which these barriers may limit host fish movement or affect dispersal/colonization capabilities of Southern Elktoe, however, it is worth noting that the populations with the most barriers are the two with lowest resilience, and the three populations with the least number of barriers had higher relative resilience. The Upper Flint and Middle Chattahoochee are large watersheds with many tributaries (USFWS, 2022).

Stressor: Altered Flow Regimes (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Alterations in flow regimes can have direct impacts on freshwater mussels and their host fish. Reduced flows can lead to stranding, low dissolved oxygen, higher contaminant concentrations in pools, and reduced reproductive success. The timing and rates of discharges from dams may interrupt the ability of the host fish to become infected with glochidia, and the settlement of the juvenile mussels once released. Host fish may rely on the connection with the floodplain for spawning, rearing, foraging and sheltering (Walsh et al. 2006, p. 12-35). This floodplain connection may also have individual and population level effects for mussels via supply food sources (e.g., phytoplankton, fine particulate organic matter, bacteria) to the system. During low flow periods this connection can be diminished (USFWS, 2022).

Stressor: Water Quality (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: The alteration of chemical and physical water quality properties such as dissolved oxygen, temperature, and suspended sediment are important water quality parameters for freshwater mussels. Their effects and general tolerance levels are discussed in Chapter 2. Summer stream temperatures in the region have presumably increased along with rising air temperatures. During summer drought, warm water temperatures and low dissolved oxygen levels are important secondary effects associated with flow reduction and cessation (Haag and Warren 2008, p. 1173), and mussel declines during drought have been attributed to these factors in the Flint River basin (Gagnon et al. 2004, p. 675; Golladay et al. 2004, pp. 499-503). Along with

other impacts such as riparian vegetation loss and urban stormwater inputs, presumably summer water temperatures and dissolved oxygen levels periodically exceed the tolerance range of sensitive mussel species. DO levels may be reduced by excessive nutrients such as nitrogen and phosphorus in the water column. In excess, these nutrients lead to algal blooms, which deplete oxygen (USFWS, 2022).

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2022. Species status assessment report for the Southern Elktoe (Alasmidonta triangulata), Version 1.1. December 2022. South Atlantic-Gulf Region, Atlanta, Georgia. 143 pp.

SPECIES ACCOUNT: *Amblema neislerii* (Fat threeridge (mussel))

Species Taxonomic and Listing Information

Listing Status: Endangered; March 16, 1988; Southeast Region (R4) (USFWS 2007a)

Physical Description

From NatureServe (2015): See Clench and Turner (1956) for full description. Large, subquadrate, inflated, solid, and heavy shelled mussel. Older, larger individuals are so inflated that their width approximates their height. The umbos are in the anterior quarter of the shell. The dark brown to black shell is strongly sculptured with seven to eight prominent horizontal parallel ridges. There are two subequal pseudocardinal teeth in the left valve and one large one one small tooth in the right valve. Nacre is bluish white to light purplish and very iridescent (Butler and Alam, 1999).

Historical Range

This species was historically distributed in the Flint River, GA; the Apalachicola River, FL; and the Chipola River, FL (USFWS 2007a).

Current Range

Flint River: Since the rediscovery of Fat Threeridge in the Flint River in 2006-2007 a small population has persisted approx. 1.2-1.9 mi in length near Newton, Georgia. Apalachicola and Chipola Rivers (FL): Habitat and dive surveys indicated robust and abundant populations in the Apalachicola and lower Chipola Rivers, and presence of the species in low numbers in the Chipola River above Dead Lakes to RKM 36.5 (USFWS, 2019)

Critical Habitat Designated

Yes; 11/15/2007.

Legal Description

On November 15, 2007, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the endangered fat threeridge (Amblema neislerii), shinyrayed pocketbook (Lampsilis subangulata), Gulf moccasinshell (Medionidus penicillatus), Ochlockonee moccasinshell (Medionidus simpsonianus), and oval pigtoe (Pleurobema pyriforme), and the threatened Chipola slabshell (Elliptio chipolaensis) and purple bankclimber (Elliptoideus sloatianus) (collectively referred to as the seven mussels) under the Endangered Species Act of 1973, as amended (Act) (72 FR 64286 - 64340). The total length of streams designated is approximately 1,185.9 river miles (river mi) (1,908.5 river kilometers (river km)).

Critical Habitat Designation

Critical habitat for the fat threeridge (mussel) (Amblema neislerii) is designated in Units 2, 7, 8 in AL, FL, and GA.

Unit 2: Chipola River, Alabama and Florida. Unit 2 includes the main stem of the Chipola River (including the reach known as Dead Lake) and six of its tributaries, encompassing a total stream length of 190.0 km (118.1 mi) in Houston County, Alabama; and in Calhoun, Gulf, and Jackson counties, Florida. The main stem of the Chipola River as designated extends from its confluence with the Apalachicola River in Gulf County, Florida, upstream 144.9 km (90.0 mi) to the confluence of Marshall and Cowarts creeks in Jackson County, Florida. A short segment of the

Chipola River that flows underground within the boundaries of Florida Caverns State Park in Jackson County, Florida, is not included in Unit 2. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The tributaries of the Chipola River included in Unit 2 are: Dry Creek, from the Chipola River upstream 7.6 km (4.7 mi) to Ditch Branch in Jackson County, Florida; Rocky Creek, from the Chipola River upstream 7.1 km (4.4 mi) to Little Rocky Creek in Jackson County, Florida; Waddells Mill Creek, from the Chipola River upstream 3.7 km (2.3 mi) to Russ Mill Creek in Jackson County, Florida; Baker Creek, from Waddells Mill Creek upstream 5.3 km (3.3 mi) to the confluence with Tanner Springs in Jackson County, Florida; Marshall Creek, from the Chipola River upstream 13.7 km (8.5 mi) to the Alabama-Florida State line in Jackson County, Florida (this creek is known as Big Creek in Alabama); Big Creek, from the AlabamaFlorida State line upstream 13.0 river km (8.1 river mi) to Limestone Creek, in Houston County, Alabama; and Cowarts Creek from the Chipola River in Jackson County, Florida, upstream 33.5 river km (20.8 river mi) to the Edgar Smith Road bridge, in Houston County, Alabama. This unit is designated for the fat threeridge (Brim Box and Williams 2000, p. 92–93; Miller 1998, p. 54), shinyrayed pocketbook (Williams unpub. data 2002; Brim Box and Williams 2000, p. 109–110; Smith unpub. data 2001; Blalock-Herod unpub. data 2000, 2003; Butler unpub. data 1993, 1994, 1999, 2000); Gulf moccasinshell (Butler unpub. data 1999, 2002; Brim Box and Williams 2000, p. 113–114; D.N. Shelton pers. comm. 1998); oval pigtoe (Butler unpub. data 1993, 1999, 2002; Brim Box and Williams 2000, p. 116–117; Williams unpub. data 2000); and Chipola slabshell (Butler unpub. data 1993, 2000; Brim Box and Williams 2000, p. 95–96). PCEs in Unit 2 are vulnerable to impacts from sedimentation, urbanization, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 7: Lower Flint River, Georgia. Unit 7 includes the main stem of the Flint River between Lake Seminole (impounded by the Jim Woodruff Lock and Dam) and the Flint River Dam (which impounds Lake Worth), and nine tributaries, encompassing a total stream length of 396.7 km (246.5 mi) in Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, GA. The main stem of the Flint River in Unit 7 extends from its confluence with Big Slough in Decatur County, GA (the approximate upstream extent of Lake Seminole) upstream 116.4 km (72.3 mi) to the Flint River Dam in Dougherty County, GA. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Lower Flint River in Unit 7 are: Spring Creek, from Smith Landing in Decatur County, Georgia (the approximate upstream extent of Lake Seminole), upstream 74.2 km (46.1 mi) to County Road 35 in Early County, Georgia; Aycocks Creek, from Spring Creek upstream 15.9 km (9.9 mi) to Cypress Creek in Miller County, Georgia; Dry Creek, from Spring Creek upstream 9.9 km (6.1 mi) to Wamble Creek in Early County, Georgia; Ichawaynochaway Creek, from the Flint River in Baker County, Georgia, upstream 68.6 km (42.6 mi) to Merrett Creek in Calhoun County, Georgia; Mill Creek, from Ichawaynochaway Creek upstream 7.4 km (4.6 mi) to County Road 163 in Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km (11.8 mi) to Little Pachitla Creek in Calhoun County, Georgia; Little Pachitla Creek, from Pachitla Creek upstream 5.8 km (3.6 mi) to Bear Branch in Calhoun County, Georgia; Chickasawhatchee Creek, from Ichawaynochaway Creek in Baker County, GA, upstream 64.5 km (40.1 mi) to U.S. Highway 82 in Terrell County, Georgia; and Cooleewahee Creek, from the Flint River upstream 15.1 km (9.4 mi) to Piney Woods Branch in Baker County, Georgia. Unit 7 is designated for the shinyrayed pocketbook (Gangloff 2005; McCafferty pers. comm. 2004; Stringfellow unpub. data 2003; Dinkins pers. comm. 2001, 2003; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Albanese pers. comm. 2003 regarding unpub. data from CCR; Andrews pers. comm. 2000; BlalockHerod unpub. data 1997; Brim Box and Williams 2000, p. 109–110; Butler unpub. data 1993), Gulf moccasinshell (Abbott pers. comm. 2005; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113–114; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), oval pigtoe (Dinkins pers. comm. 2001; Golladay unpub. data 2001, 2002; Andrews pers. comm. 2000; Brim Box and Williams 2000, p. 116– 117; P. Johnson unpub. data 1999; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), and purple bankclimber (S. Carlson unpub. data 2002; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 7 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ''Special Management Considerations or Protections.''

Unit 8: Apalachicola River, Florida. Unit 8 includes the main stem of the Apalachicola River; two distributaries (channels flowing out of the main stem), and three tributaries, encompassing a total stream length of 155.4 km (96.6 mi) in Calhoun, Franklin, Gadsden, Gulf, Jackson, and Liberty counties, Florida. The main channel of the Apalachicola River in Unit 8 extends from the downstream end of Bloody Bluff Island (river mile 15.3 on U.S. Army Corps of Engineers Navigation Charts) in Franklin County, Florida, upstream to the Jim Woodruff Lock and Dam in Gadsden and Jackson counties, Florida (the river is the county boundary). The upstream extent of each distributary within the unit is its point of departure from the main channel of the Apalachicola River, and its downstream extent is the landmark listed. The two distributaries of the Apalachicola River in Unit 6 are: Chipola Cutoff, from the Apalachicola River in Gulf County, Florida, downstream 4.5 km (2.8 mi) to its confluence with the Chipola River in Gulf County, Florida; and Swift Slough, from the Apalachicola River in Liberty County, Florida, downstream 3.6 km (2.2 mi) to its confluence with the River Styx in Liberty County, Florida. The downstream extent of each tributary within the unit is its confluence (mouth) with the main channel of the Apalachicola River, and its upstream extent is the landmark listed. The three tributaries of the Apalachicola River within the unit are: River Styx from the mouth of Swift Slough in Liberty County, Florida, downstream 3.8 km (2.4 mi) to its mouth; Kennedy Slough from ¥85.07 longitude, 30.01 latitude in Liberty County, Florida, downstream 0.9 km (0.5 mi) to its confluence with Kennedy Creek; and Kennedy Creek from Brushy Creek Feeder (¥85.06 longitude, 30.01 latitude) in Liberty County, Florida, downstream 1.1 km (0.7 mi) to its mouth. Unit 8 is designated for the fat threeridge (Brim Box and Williams 2000, p. 92–93; Williams unpub. data 2000; Miller 1998, p. 54, 2000; Richardson and Yokley 1996, p. 137; Flakes 2001) and purple bankclimber (Brim Box and Williams 2000, p. 105– 106; Miller 1998, p. 55, 2000; Richardson and Yokley 1996, p. 137; Butler unpub. data 1993; Flakes 2001). PCEs in Unit 8 are vulnerable to impacts from sedimentation, hydrologic alteration, and pollution, as described under ''Special Management Considerations or Protections.''

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements of critical habitat are:

(i) A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);

(ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay;

(iii) Permanently flowing water;

(iv) Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387); and

(v) Fish hosts (such as largemouth bass, sailfin shiner, brown darter) that support the larval life stages of the seven mussels.

Special Management Considerations or Protections

The features essential to each of the seven mussel species contained within the areas of this designation may require special management considerations or protections due to known or probable threats from these activities.

Management considerations to deal with sedimention include protecting streams from sedimentation through application of agricultural and forestry best management practices, avoiding soil and vegetation-disturbing activity in the riparian zone, restoring unstable stream channels and other erosive areas, and other practices that prevent or reduce erosion.

Management considerations to deal with the threat of channel instability include avoiding soil- and vegetation-disturbing activity in the riparian zone, limiting impervious surface area, and other urban storm water runoff control methods. Sand and gravel mining (unit 3), dredging and channelization (unit 8), and dam construction (unit 5) may also affect channel stability.

Measures to deal with construction and operation of dams, water withdrawals, and water diversions include water conservation and operational strategies that manage water storage capacity and water demands in combination to minimize departures from the natural flow regime.

Management considerations to deal with the threat of pollution include applying agricultural and forestry best management practices, preserving native vegetation in riparian zones, maintaining septic systems, and taking other measures to minimize pollutant-laden runoff to streams.

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on the effective date of this rule and not containing one or more of the primary constituent elements.

Life History

Feeding Narrative

Larvae: From NatureServe (2015): Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species. Transformation of glochidia required 10 to 14 days at 73.4F (Butler and Alam, 1999; Butler et al., 2003; O'Brien and Williams, 2002). From USFWS (2007b): The fat threeridge lacks mantle modifications or other morphological specializations that would serve to attract host fishes and appears to be a host-fish generalist that may infect fishes of at least three different fish families. Glochidia transformed to juveniles under laboratory conditions on five of seven fish species tested: weed shiner (Notropis texanus), bluegill (Lepomis macrochirus), redear sunfish (L. microlophus), largemouth bass (Micropterus salmoides), and blackbanded darter (Percina nigrofasciata) (O’Brien and Williams 2002, p. 152). Transformation of glochidia required 10 to 14 days at 73.4F (Butler and Alam, 1999; Butler et al., 2003; O'Brien and Williams, 2002).

Adult: NatureServe (2015): Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974).

Reproduction Narrative

Adult: Shells collected in 2006 ranged from 2 - 27 years old (USFWS 2007a). From NatureServe (2015): Tachytictic, gravid in Florida when water temperatures reached 75.2F in late May and June. Suggests summer releaser. Glochidia released in white sticky web-like mass, which expands and wraps around a fish, thus facilitating attachment.

Environmental Specificity

Adult: Narrow (inferred from USFWS 2007b)

Habitat Narrative

Adult: From USFWS (2007a): The fat threeridge is generally found at water depths less than 5 feet in the Apalachicola River (Miller 2005; EnviroScience 2006a; EnviroScience upubl data 2006). From NatureServe (2015): Found in the main channels of small to large rivers in slow to moderate current, not their tributaries; does not tolerate impoundments. Substrate varies from gravel to cobble to a mixture of sand and sandy mud (Butler et al., 2003). Heard (1979) notes its typical occurrence "in muddy sand in moderate current". Sizable population found in slow current over muddy sand with numerous cypress stumps at Chipola River below Dead Lake. It usually favors the side of the river that is not eroding but rather is receiving deposition of sand and silt, but not in huge amounts as seen on major sandbars; such sites usually support young willows (Alderson, 2009). Strayer (1999) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that displayed little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. From USFWS (2007b): The primary constituent elements of critical habitat for the fat threeridge are (i) geomorphically stable stream channel; (ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay; (iii) Permanently flowing water; (iv) Water quality that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Seasonal movement (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: From NatureServe (2015): Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate although some passive movement downstream may occur during high flows. Dispersal occurs while the glochidia are encysted on their host (probably a fish). Movement is confined to either vertical movement burrowing deeper into sediments though rarely completely beneath the surface, or horizontal movement in a distinct path often away from the area of stimulus. Vertical movement is generally seasonal with rapid descent into the sediment in autumn and gradual reappearance at the surface during spring (Amyot and Downing, 1991; 1997). Horizontal movement is generally on the order of a few meters at most and is associated with day length and during times of spawning (Amyot and Downing, 1997). Such locomotion plays little, if any, part in the distribution of freshwater mussels as these limited movements are not dispersal mechanisms.

Population Information and Trends

Population Trends:

Declining (USFWS 2007a)

Population Size:

18,101+ (USFWS 2007a)

Population Narrative:

From USFWS (2007a): Species status is declining. The total number of fat threeridge in Swift Slough is likely greater than 18,101.

Threats and Stressors

Stressor: Habitat modification and degradation (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2007a): The declining range and abundance is mostly due to changes in riverine habitat resulting from dams, dredging, mining, channelization, pollution, sedimentation, and water withdrawals. Sedimentation and water pollution continue to be an almost ubiquitous threat in the range of this mussel.

Stressor: Insufficient host fish densities (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2007a): Riverine fish populations in the Southeast generally have been adversely affected by a variety of the same habitat alterations that have contributed to the decline of the region's mussel fauna (Etnier 1997; Neves et al. 1997; Warren et al. 1997).

Stressor: Non-indigenous species (USFWS 2007)

Exposure:
Response:
Consequence:
Narrative: From USFWS (2007a): Flathead catfish and blue catfish have been introduced in the ACF. These fishes are known to consume mussels and fishes and negatively impact fish populations that may be hosts for endangered unionids. Monitoring data from FWS indiate that populations of redbreast sunfish, snail and spotted bullhead catfish, and other species have declined since the late 1980s, which may be the result of predation by the flathead catfish (T. Hoehn, pers comm.).

Recovery

Reclassification Criteria:
An increase of 26 RM in the Flint River Basin to achieve occupation in 50 percent of its historical range. An increase from 0 to 3 subpopulations in the Flint River Basin is necessary to support the range increase and to establish a minimum of 3 subpopulations per watershed (USFWS 2007a).

Delisting Criteria:
1. At least 4 populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (Factors A and E) (USFWS, 2019).

2. At least 1 population occupies each of the Flint and Chipola sub-basins, In the Apalachicola sub-basin, at least 1 population occupies 2 of the 3 delineated units (USFWS, 2019).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (USFWS, 2019).

Recovery Actions:
- Criteria 1 and 2. Populations that exhibit a stable or increasing trend, natural recruitment and multiple age classes will be more resilient to stochastic events. To achieve redundancy and representation for the Fat threeridge, these resilient populations must exist in each of the 3 historic river basins. In the Apalachicola River, the species should be adequately distributed and habitat represented in the 3 defined units. One population in each of the Flint and Chipola Rivers, and 2 populations among the 3 units in the Apalachicola, will result in 4 populations necessary to ensure the species will no longer require protection under the Act (USFWS, 2019)
- Criterion 3: Abatement of the threats to the Fat threeridge will allow population to become stable and contribute to the viability of the species, Threats identified include: degraded water quality, insufficient water quantity, sedimentation, loss of habitat stability, and contaminants. Threat reduction or management will improve the primary habitat constituents identified increasing the viability of the species into the foreseeable future (USFWS, 2019).
- 1. The subpopulation recovery criteria defining a subpopulation as a site is vague and less meaningful than actual density or population estimates. As USFWS acquires more information about population characteristic, USFWS should revise recovery criteria. The USFWS recommends using quantitative methods to monitor changes in population size with each sub-basin (USFWS 2007a).

- 2. Define "viable subpopulation" through implementation of Recovery Tasks 1.3.6, 1.3.7, and 1.3.8 (USFWS 2007a).
- 3. Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders (USFWS 2007a).
- 4. Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies (USFWS 2007a).
- 5. Work with the EPA and States to modify numerical water quality criteria for ammonia and copper (USFWS 2007a).
- 6. Develop and implement a program to monitor subpopulation levels and habitat conditions of existing subpopulations (USFWS 2007a).
- 7. Continue re-evaluating threats to these mussels (USFWS 2007a).

References

USFWS 2007a. Fat Three ridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus penicillatus) Ochlocknee Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 16, 2016). USFWS. 2019. Amendment to the USFWS. 2003. Recovery Plan for Fat Threeridge (Amblema neisleri).

U.S. Fish and Wildlife Service. 2007. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Final rule. 72 FR 64286 - 64340 (November 15, 2007).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 16, 2016)

USFWS 2007b. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages

Final Rule. 77 Federal Register 220. November 15, 2007. pp. 64286 - 64340.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 16, 2016)

USFWS 2007a. Fat Three ridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus penicillatus) Ochlocknee Moccasinshell (Medionidus simpsonianus)

Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida.

USFWS. 2007a. Fat Three ridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus penicillatus) Ochlocknee Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida.

USFWS. 2019. Amendment to the USFWS. 2003. Recovery Plan for Fat Threeridge (Amblema neisleri).

USFWS 2007a. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office, Panama City, Florida.

SPECIES ACCOUNT: *Arkansia wheeleri* (Ouachita rock pocketbook)

Species Taxonomic and Listing Information

Commonly-used Acronym: ORP

Listing Status: Endangered; 10/23/1991; Southwest Region (R2) (USFWS, 2016)

Physical Description

A freshwater mussel with a subovate, brown to black shell.Not sexually dimorphic (both sexes appear the same). Shell is subcircular to subovate to subquadrate in profile, truncated posteriorly, moderately inflated, moderately heavy,somewhat thickened anteriorly, up to 6 mm thick, and half as thick posteriorly. The periostracum (outer shell layer) is chestnut-brown to black with a silky luster, and appears slightly iridescent when wet. The umbos are prominent, and project over a well-defined lunule depression. The posterior half of the shell is sculptured by irregular, oblique ridges that are sometimes crossed by smaller ridges or sometimes indistinct. Beak sculpturing, rarely intact, is very restricted and consists of weak double loops. The nacre (inner shell lining) is usually salmon-colored above the pallial line, white to light blue below, with a dark prismatic border. The shell has the so-called "complete" dentition for unionid bivalves, with all hinge teeth usually well-developed. The anterior left pseudocardinal and right pseudocardinal are both curved and parallel to the lunule; the posterior left pseudocardinal joins a conspicuous, flange-like, interdental projection that runs to the lower lateral. The lateral teeth are moderately short; the upper left lateral is sometimes reduced (USFWS, 2004). LENGTH:11 WIDTH: 8 (NatureServe, 2015)

Historical Range

See current range/distribution

Current Range

The ORP is a freshwater mussel endemic to the Red River basin (Little, Kiamichi, and Ouachita rivers) in Arkansas, Oklahoma, and Texas.

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Adult freshwater mussels have long been considered suspension-feeders, siphoning phytoplankton, diatoms, and other microorganisms from the water column (Fuller 1974). Recent evidence emphasizes the importance of the uptake and assimilation of detritus and bacteria over that of algae to riverine mussels (Silverman et al. 1997; Nichols and Garling 2000). It also has been surmised that dissolved organic matter may be a significant source of nutrition (Strayer et al. 2004). Their diet may more accurately consist of a mixture of algae, bacteria, detritus, and microscopic animals. Such an array of foods containing essential long-chain fatty acids, sterols, amino acids, and other biochemicals may be necessary to supply total nutritional needs (Strayer et al. 2004). For their first several months, juvenile mussels employ foot (pedal) feeding and are thus deposit feeders, although they may also filter interstitial pore water

(Yeager et al. 1994). Ongoing propagation efforts for ORP have further documented the importance of fine sediments and pedal feeding for this species (Barnhart 2010; P. Johnson, ADCNR, pers. comm. 2011). Growth and longevity – Growth rates for mussels tend to be relatively rapid for the first few years (Chamberlain 1931; Scruggs 1960; Negus 1966) then slow appreciably (Bruenderman and Neves 1993; Hove and Neves 1994). The relatively abrupt slowing in growth rate occurs at sexual maturity, probably as a result of energy being diverted from growth to gamete production (Baird 2000). Growth rates vary among species; heavy-shelled species grow slowly relative to thin-shelled species (Coon et al. 1977; Hove and Neves 1994). No quantitative information on the longevity of ORP is available.

Reproduction Narrative

Adult: Reproductive anatomy is likely similar to other members of the subfamily Anodontinae, as discussed by Ortmann (1912). Seagraves (2006) and Barnhart (2010) provide the most detailed description of ORP reproductive biology (host fish, glochidia description, etc). ORP glochidia have very long stylets (hooks) used to attach to fish fins, tails, scales, or gills. Sex ratios in mussels generally do not differ significantly from 1:1; although some Quadrula populations tend to be male-biased (Haag and Staton 2003). Age at sexual maturity for the ORP is unknown, but Rabbitsfoot populations west of the Mississippi River reach sexual maturity between the ages of 4 to 6 years (Fobian 2007). Rabbitsfoot exhibit seasonal movement towards shallower water during brooding periods, a strategy to increase host fish exposure but one that also leaves them more vulnerable to predation and fluctuating water levels, especially downstream of dams (Fobian 2007; Barnhart 2008, pers. comm.). It is a short-term brooder, with females brooding between May and late August (Fobian 2007). Males expel clouds of sperm into the water column, which are drawn in by females through their incurrent siphons. Fertilization takes place internally, and the resulting zygotes develop into specialized larvae termed glochidia within the female's gills. Similar to other species of Quadrula, the Rabbitsfoot uses all four gills as a marsupium (pouch) for its glochidia (Fobian 2007). Female Rabbitsfoot release glochidia as conglutinates, which mimic flatworms or similar fish prey. Fertilization success is apparently influenced by mussel density and flow conditions (Downing et al. 1993). This potentially indicates that small populations occurring in low flow streams (or in streams experiencing drought conditions during the reproductive period) may experience reduced fertilization rates. Fecundity (capacity of abundant production) in river basins west of the Mississippi River ranged from 46,000 to 169,000 larvae per female (Fobian 2007). From parasitic glochidia to free-living juveniles – The larvae of the family Unionidae are specialized for a parasitic existence, and referred to as glochidia. Glochidia generally spend from two to six weeks parasitizing the host fish, the duration of encystment being dependent on the mussel species and water temperature (Zimmerman and Neves 2002). Suitable fish hosts for Rabbitsfoot populations west of the Mississippi River include Blacktail Shiner (Cyprinella venusta) from the Black and Little River and Cardinal Shiner (Luxilus cardinalis), Red Shiner (C. lutrensis), Spotfin Shiner (C. spiloptera), and Bluntface Shiner (C. camura) from the Spring River, but host suitability information is lacking for the eastern range (Fobian 2007). In addition, Rosyface Shiner (Notropis rubellus), Striped Shiner (L. chrysocephalus), Rainbow Darter (Etheostoma caerulium) and Emerald Shiner (N. atherinoides) served as hosts for Rabbitsfoot, but not in all stream populations tested (Fobian 2007; Watters et al. 2009). Newly metamorphosed juveniles drop off to begin a free-living existence on the stream bottom. They must drop into suitable habitat or they will die.

Habitat Narrative

Adult: The ORP is a freshwater mussel endemic to the Red River basin (Little, Kiamichi, and Ouachita rivers) in Arkansas, Oklahoma, and Texas.

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-Migratoy

Population Information and Trends

Population Size:

The ORP population estimate was 420 ± 730

Population Narrative:

Gordon and Harris (1983) collected relict shells of ORP from the Little River in Arkansas, just west of Arkansas Highway 41 and 6.4 km (4.0 miles) northwest of U.S. Highway 59/71, both sites located along the boundary between Little River and Sevier Counties. Clarke (1987) found a small number of live individuals in a 1 km (0.7 river mile) reach of the Little River running east from the Oklahoma-Arkansas state line, Little River and Sevier Counties. He believed the species might exist through a defined section of about 8 km (5 river miles) extending east from the state line. Clarke (1987) estimated the Little River population to be less than 100 individuals. In the Arkansas portion of their survey, Vaughn et al. (1995) found an ORP shell approximately 6.5 km (4 river miles) east of the Oklahoma-Arkansas state line, Little River and Sevier Counties, in 1994. The Service and Arkansas Game and Fish Commission (AGFC) conducted additional mussel surveys in the Little River during 2006 and 2008. They systematically surveyed 14 sites between Millwood Reservoir and the Arkansas - Oklahoma State Line (~ 56 rkm) and found 28 species. The number of species per site ranged from 7 to 22 with a mean of 14.7. One live and two dead ORP were encountered during the survey. Quantitative sampling of one large mussel assemblage occupying 15,525 m2 and containing live ORP resulted in collection of 1,067 individuals representing 21 species. The ORP population estimate was 420 ± 730, and the mussel community numerical standing crop estimate was 447,404 ± 73,065 (B. Posey, AGFC, pers. comm. 2008). In July, 2013 and August, 2014, Josh Seagraves with AHTD performed surveys to assess potential impacts to threatened and endangered species at the HWY 41 bridge crossing. In the 2013 survey, 277 mussels representing 21 species were collected in 106 minutes of search time. No living listed species were collected; however, one relict shell of a Rabbitsfoot was collected. In the 2014 survey, 326 mussels representing 21 species were collected within 31 meter squared quadrat quantitative sampling.

Threats and Stressors

Stressor: Modification and Destruction of Habitat
Exposure:
Response:
Consequence:
Narrative: The central reason for the decline of freshwater mussels is the modification and destruction of their habitat, especially from sedimentation, dams, and degraded water quality (Neves et al. 1997). Dams eliminate and alter river flow within impounded areas, trap silt leading to increased sediment deposition, alter water quality, change hydrology and channel

geomorphology, decrease habitat heterogeneity, affect normal flood patterns, and block upstream and downstream movement of mussels and fish (Layzer et al. 1993; Neves et al. 1997; Watters 2000). Within impounded waters, decline of mussels has been attributed to direct loss of supporting habitat, sedimentation, decreased dissolved oxygen, temperature levels, and alteration in resident fish populations (Neves et al. 1997; Pringle et al. 2000; Watters 2000). Flow modification – Closely related to ORP and Rabbitsfoot habitat stability are aspects of flow. Flows also can affect other processes such as delivery of oxygen and food items to mussels, removal of wastes, transport and concentration of sperm cells, sustained immersion of juveniles and adults, protection from heat stress, and formation of stream habitats. In the case of some mussel species and environments, such relationships have even been studied to varying degrees (Vannote and Minshall 1982, Hartfield and Ebert 1986, Layzer and Madison 1995, Tippit et al. 1997, Strayer 1999b). In the case of the ORP, however, the complex relationships involved are not known to an extent that is useful to many flow management decisions. In addition, native stream fish communities have shown adaptations to flooding and other elements of natural flow regimes (Ross and Baker 1983, Wootton et al. 1996), raising the possibility that host fish for ORP and Rabbitsfoot might be affected by flow modifications.   Water withdrawal, industrial and agricultural development – Water withdrawal for industrial, agricultural and recreational purposes, lack of adequate riparian buffers, construction and maintenance of state and county roads, and non-point source pollution arising from a broad array of activities are the primary threats degrading suitable habitat for ORP and Rabbitsfoot. Traditional farming practices and associated poor land use practices contribute many pollutants, and agriculture affects 72 percent of impaired river km in the United States (Neves et al. 1997). Nutrients, bacteria, pesticides, and other organic compounds generally are found in higher concentrations in agricultural areas than forested areas. Nutrient concentrations in streams may result in increased algal growth in streams, and a related alteration in fish community composition. Major agricultural activities within the Little River watershed include row crop, poultry, cattle, and swine. Population fragmentation and isolation – Population fragmentation and isolation prohibit the natural interchange of genetic material between populations and, thus, are susceptible to genetic drift, inbreeding depression, and stochastic changes the environment. Inbreeding depression can result in early mortality, decreased fertility, smaller body size, loss of vigor, reduced fitness, and various chromosome abnormalities. Population isolation prohibits the natural interchange of genetic material between populations, and small population size reduces the reservoir of genetic diversity within populations, which can lead to inbreeding depression (Avise and Hambrick 1996). Sedimentation – Excessive sediments may adversely affect riverine mussel populations requiring clean, stable streams (Ellis 1936; Brim Box and Mossa 1999). Adverse effects resulting from sediments have been noted for many components of aquatic communities. Potential sediment sources within a watershed include natural events and anthropogenicactivities that disturb the land surface.   Chemical contaminants – Chemical contaminants are ubiquitous in the environment and are considered a major threat in the decline of mussel species (Richter et al. 1997; Strayer et al. 2004; Wang et al. 2007a; Cope et al. 2008). Chemicals enter the environment through point and nonpoint discharges including spills, industrial and municipal effluents, and residential and agricultural runoff. These sources contribute organic compounds, heavy metals, nutrients, pesticides, and a wide variety of newly emerging contaminants such as pharmaceuticals to the aquatic environment. Rabbitsfoot and ORP are susceptible to chemical contaminants that degrade water and sediment quality and subsequently may result in adverse effects.

Recovery

Reclassification Criteria:
The Ouachita rock pocketbook may be reclassified as threatened by protecting the Kiamichi River population, and by reestablishing and protecting distinct viable populations in two streams outside the Kiamichi River system. Protection involves elimination of present and foreseeable threats (e.g., deauthorizing Tuskahoma Reservoir), determining biological requirements, maintenance of suitable habitats and specific fish host(s), and verification of conditions through monitoring.

Recovery Priority Number 5C (USFWS, 2018)

Delisting Criteria:
The interim criterion for delisting requires establishment and protection of distinct viable populations in four stream systems historically inhabited. The delisting criterion may be revised as additional information becomes available.

Recovery Actions:
- Preserve existing population and habitat in the Kiamichi River.
- Determine if other viable populations exist, preserve any population(s) found; restore degraded habitats.
- Determine reproduction, habitat, genetics, and captive propagation requirements.
- Establish, if necessary, and protect two populations outside the Kiamichi River (for reclassification as threatened).
- Develop an outreach program.
- Develop an enhanced management program.
- Establish, if necessary, and permanently protect viable populations in four stream systems historically inhabited by the species (for delisting).
- The most important conservation action remaining is protection and restoration of instream and riparian habitat (including water quality and quantity) throughout the watershed at a sufficient level to sustain and/or expand existing populations and when necessary augment and reintroduce populations into areas with suitable habitat.
- 1. Obtain increased cooperative participation in implementation of actions already identified within the ORP's existing recovery plan. Since initial listing of the ORP, only relatively minor expenditures have been made on actions to recover this species. Unless planned recovery actions are adequately implemented, this endangered species will continue its decline toward extinction. While the Service leads recovery planning and helps implement many recovery actions, the recovery plan for the species also identifies major roles for other stakeholders in performing recovery actions. Increased participation in recovery efforts by all responsible stakeholders will be necessary to advance recovery of the ORP. Examples of planned actions that should receive additional emphasis include use of existing protections (1.1 and 3.1), increases in habitat protection through the use of cooperative projects (1.23 and 3.22), upgrade protection through water quality management programs (1.24 and 3.23), and better implement treatments for identified threats (9.3). Galbraith et al. (2005, p. 11; 2008, p. 49) called for increased efforts to minimize impacts on populations of the ORP and associated rare mussels. In view of the recently discovered lower Little River population, it is important to ensure that protection actions performed under group 3 of the recovery plan include adequate protection of the

lower Little River population and its habitats. Seagraves (2006, pp. 49-50) recommended the performance of additional monitoring, surveys, and research, and establishment of a watershed-wide management plan, all of which are actions included in the species’ recovery plan (USFWS 2004). Davidson et al. (2014, p. 30) and Davidson (2017, p. 12-13) recommended improved operation of federal reservoirs and implementation of land practices to reduce sediment runoff, which also are listed within the recovery plan (USFWS 2004) (USFWS, 2018). 2. Improve and expand monitoring of ORP populations and habitat. In particular, conduct studies of the lower Little River population, to better characterize its size and condition, and factors that may threaten the population. Include new surveying of neglected portions of the species’ range and waters plausibly containing unknown occurrences of the ORP, such as the lower Kiamichi River downstream of Hugo Reservoir. Harris et al. (2009) specifically named the Cossatot and Saline rivers, major tributaries of the Little River, as inadequately surveyed waters that may harbor ORP populations. Davidson et al. (2014, pp. 30-31) and Davidson (2017, p. 13) made several specific recommendations regarding monitoring of the ORP, other mussels, and habitat. Monitoring of all populations should be designed to provide information that is specifically useful to indicating the degree of fulfillment of recovery criteria for the ORP. (USFWS, 2018). 3. Continue investigation of the ORP’s habitat needs, especially as relate to successful reproduction, as well as feasible means of supporting those needs through improved pollution controls, improved reservoir operations, reservation of environmental flows, and other management of human impacts. In advance of identifying all minimum and optimum conditions for the species, support the species conservatively by restoring and protecting high quality habitat conditions. Rust et al. (2006, p. 11) recommended additional geomorphological research and monitoring, and also recommended the use of Sardis Reservoir releases to mimic the Kiamichi River’s natural flow and sediment regimes. Davidson (2017, p 12) recommended evaluating whether release conditions at DeQueen Reservoir (an impoundment on the Rolling Fork of the Little River) significantly affect mussel distribution and abundance, and similarly whether land use in the Rolling Fork basin is a significant factor. He also recommended identifying other factors that importantly affect mussel dispersal, spatial distribution patters, and genetic connectivity in the Little River. Davidson (2017, p. 12) additionally recommended increasing (i.e., restoration and augmentation) of riparian forests as a means of minimizing river warming and evaporation, which climate change is expected to increase. Anti-degradation provisions available in state water quality standards should be used in drainages inhabited by the ORP to protect natural water quality rather than allowing that quality to be degraded to levels minimally tolerated by aquatic life. New investigations should build on previous research to better define comprehensive habitat needs of the species, and to integrate those needs into broad monitoring and management programs. Initial progress will depend on substantial research, but also will require participation by water managers, users, land owners, and other stakeholders to restore conditions needed by the species (USFWS, 2018). 4. Continue investigation of the species’ life history, and methods of artificially supporting the species’ reproduction and recruitment. This work has value to multiple potential purposes, but most immediately as an interim means of sustaining and augmenting remaining populations until conditions supporting natural reproduction and recruitment are restored in native habitats. Barnhart (2009) identified some specific investigative questions and management strategies related to successful reproduction and recruitment (USFWS, 2018). 5. Assess and evaluate genetic characteristics of populations of the ORP across its range. This information is needed in order to evaluate intraspecies diversity and local population health, and to soundly guide many key management actions. Technological advances in recent years have both increased the power of genetic analyses and reduced concerns for potentially harming individual mussels in the conduct of genetic sampling (USFWS, 2018).

References

USFWS 2016. Status of the Species and Critical Habitat: Arkansia wheeleri (Ouachita Rock Pocketbook). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS. 2004. Ouachita Rock Pocketbook (Arkansia wheeleri Ortmann and Walker, 1912) Recovery Plan. Albuquerque, New Mexico. vi + 83p. + A-1-85p.

USFWS. 2018. Ouachita Rock Pocketbook Arcidens (=Arkansia) wheeleri (Ortmann and Walker 1912). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southwest Region Oklahoma Ecological Services Field Office Tulsa, Oklahoma. 58 pp.

SPECIES ACCOUNT: *Cumberlandia monodonta* (Spectaclecase (mussel))

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Large mussel that reaches at least 9.25 inches in length. Elongated shell that is sometimes curved and moderately inflated with the valves being solid and moderately thick.

Taxonomy

Williams et al. (2017, p. 26, 45) proposed a change in the family Margaritiferidae: the placement of the formerly monotypic genus Cumberlandia in the synonymy of Margaritifera. Therefore, Cumberlandia monodonta has been reassigned to Margaritifera monodonta (Say, 1829) (Williams et al. 2017, p. 36). (USFWS, 2019)

Historical Range

The spectaclecase occurred historically in at least 44 streams in the Mississippi, Ohio, and Missouri River basins (Butler 2002, p. 6, Heath 2008, pers. comm.) and its distribution comprised portions of 14 States (Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Ohio, Tennessee, Virginia, West Virginia, and Wisconsin).

Current Range

The spectaclecase occurs in the Ohio River in the vicinity of Louisville, Kentucky, and adjacent Indiana), and the Wabash River (probably the lower portion in Illinois and Indiana). ynthesis The spectaclecase is a federally listed endangered species that is currently considered extant in 20 streams in Alabama, Arkansas, Illinois, Kentucky, Minnesota, Missouri, Tennessee, Virginia, West Virginia, and Wisconsin. (USFWS, 2019)

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

<u>Larvae:</u> Larval mussels (i.e., glochidia) require a host.

<u>Juvenile:</u> For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Their life cycle includes a brief, obligatory, parasitic stage on a host organism, typically fish. Eggs develop into microscopic larvae (glochidia) within special gill chambers of the female. The female expels the mature glochidia, which must attach to an appropriate host species (generally a fish) to complete development. Host specificity varies among margaritiferids and unionids. Some species appear to use a single host, while others can transform on several host species. Following successful infestation, glochidia encyst (enclose in a cyst-like structure), remain attached to the host for several weeks, and then drop off as newly transformed juveniles. The spectaclecase is thought to release larvae (glochidia) from early April to late May in the Meramec and Gasconade Rivers, Missouri (Baird 2000, p. 26). Gordon and Smith (Gordon and Smith 1990, p. 409) reported the species as producing two broods, one in spring or early summer and the other in the fall, in the Meramec River. The spectaclecase life cycle includes a brief, obligatory parasitic stage on an unknown host organism. glochidia are released in conglutinates (gelatinous structures containing numerous glochidia and analogous to cold capsules). Two fish hosts for spectaclecase were confirmed in 2017; mooneye (Hiodon tergisus) and goldeye (H. alosoides) (Sietman et al. 2017, p. 18). Host research is now focused on these two species, although efforts continue to identify additional hosts. Identification of host species now allows for propagation of juvenile mussels. Research continues on husbandry of host fish and juvenile mussels in laboratory conditions (USFWS, 2019)

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The spectaclecase is a freshwater mussel that generally inhabits large rivers, and is typically found aggregated in microhabitats sheltered from the main force of current, such as under slab boulders or bedrock shelves. It occurs in substrates from mud and sand to gravel, cobble, and boulders in relatively shallow riffles and shoals with a slow to swift current.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Juvenile: unlikely

Adult: unlikely

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Unlike most species that move about to some degree, the spectaclecase may seldom if ever move except to burrow deeper and may die from stranding during droughts (Oesch 1984, p. 17). At least one recent study, however, indicated that spectaclecase can be quite active; specifically, relocated individuals moved to more suitable habitat (Dunn et al. 1999, pp.175, 177). Mostly dispersed by host. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

negative 55 percent

Population Size:

unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Area of occupancy of this species has been drastically reduced by approximately 55 percent with continuing decline of populations. Range extent has also been reduced as the species is extirpated from several states (Indiana, Kansas, Nebraska, Ohio) and many of the remaining populations have poor or no viability. The species has largely been reduced to a relatively few disjunct sites, some of which may not be capable of reproduction either through loss of fish hosts or adverse environmental conditions (e.g., hypolimnetic release from reservoirs). Only the Gasconade and Meramec Rivers of Missouri and perhaps also in the Upper Clinch River, Tennessee are fairly stable for now with the remaning populations in decline. Following these criteria (above), as of 2017-2018 there are 5 “stronghold”, 5 “weakened”, 3 “notable”, and 15 “unknown” spectaclecase populations (Table 1). A few rivers were evaluated in multiple segments, and therefore may have fallen into multiple categories (e.g., if data were notably dissimilar in different stream reaches) (USFWS, 2019).

Threats and Stressors

Stressor: Impoundments
Exposure:
Response: alter water quality and flow, impair habitats and increase fragmentation and isolation of mussel populations; creates habitat for invasive zebra mussels
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Dams and impoundments are considered a threat of high magnitude to the spectaclecase because they alter water quality and flow, impair habitats and increase fragmentation and isolation of mussel populations. Although most impoundment and channelization of rivers and streams occurred in the past, the ongoing effects caused by such activities pose an imminent threat of high magnitude to the spectaclecase because of altered habitats, sedimentation and the subsequent transformations in biological communities that occurred due to these changes. Likewise, continued maintenance of channelized waterways adds to these threats by further increasing sedimentation and siltation. Additionally, impoundments create slow-moving deep water habitat ideal for harboring certain exotic species (e.g., zebra mussels).

Stressor: Channelization
Exposure:
Response:
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Individuals are buried and/or incidentally relocated to disposal site of dredge material (i.e., unsuitable habitat).

Stressor: Contaminants
Exposure:
Response: reduce filtration efficiency, decrease growth and reproduction and induce behavioral changes
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Small populations of spectaclecase are vulnerable to the threat of detrimental chemical spills. Furthermore, exposure of mussels to low but ubiquitous concentrations of contaminants may not be immediately lethal but can reduce filtration efficiency, decrease growth and reproduction and induce behavioral changes in all life stages over time.

Stressor: Mining
Exposure:
Response: effects of water quality and habitat impairments; increase in siltation, change the hydrology
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: In-stream sand and gravel mining represents an imminent threat of moderate to high magnitude to the spectaclecase due to the effects of water quality and habitat impairments. Coal, oil and gas mining are a threat because these activities can cause increase in siltation, change the hydrology and alter water quality. Similarly, heavy metal contaminated sediments associated with lead mining have negatively impacted mussel populations along several miles of

the Big River, Missouri (Roberts et al. 2009, p. 20).

Stressor: Sedimentation
Exposure:
Response: Reduce feeding and respiratory efficiency; vector for chemical contaminants
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Excess sedimentation is considered an imminent threat of high magnitude to the spectaclecase because it can reduce feeding and respiratory efficiency of these species. Furthermore, sediments can be a vector for chemical contaminants.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Point source discharges within the range of the spectaclecase have been reduced since the inception of the Clean Water Act (33 U.S.C. 1251 et seq.), but this may not provide adequate protection for filter feeding organisms that can be impacted by extremely low levels of contaminants. There is no specific information on the sensitivity of the spectaclecase to common industrial and municipal pollutants, and very little information on other freshwater mussels. Therefore, it appears that a lack of adequate research and data prevents existing regulations, such as the Clean Water Act (administered by the EPA and the Corps), from being fully used or effective. The U.S. Army Corps of Engineers retains oversight authority and requires a permit for gravel-mining activities that deposit fill into streams under section 404 of the Clean Water Act. Additionally, a Corps permit is required under section 10 of the Rivers and Harbors Act (33 U.S.C. 401 et seq.) for navigable waterways including the lower 50 miles (80 km) of the Meramec River. However, many gravel-mining operations do not fall under these two categories.

Stressor: Invasive species
Exposure:
Response: zebra mussel: impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, and locally depleting food resources and increasing waste products. Black carp eats spectaclecase.
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: The exotic species that poses the most significant threat to the spectaclecase is the zebra mussel. Zebra mussels impact native mussels primarily through direct fouling of the shells of live native mussels. Zebra mussels attach in large numbers to the shells of live native mussels and are implicated in the loss of entire native mussel beds. Fouling impacts include impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, and locally depleting food resources and increasing waste products. Heavy infestations of zebra mussels on native mussels may overly stress the animals by reducing their energy stores. Zebra mussels may also reduce food concentrations to levels too low to support reproduction, or even survival in extreme cases. The spectaclecase's colonial tendency could allow for very large numbers to be affected by a single favorable year for zebra mussels. Zebra mussels are established throughout the upper Mississippi, lower St. Croix, Ohio, and Tennessee Rivers, overlapping much of the current range of the spectaclecase. The black carp (Mylopharyngodon piceus) is a potential threat to the spectaclecase (Strayer 1999, p. 89); it has been introduced into North America since the 1970s. Black carp are known to eat clams (Corbicula spp.) and unionid mussels and snails. Several other Asian carp species, which may

disrupt aquatic food chains, are present in the some of the rivers with extant spectaclecase populations (e.g., Mississippi River, Chick and Pegg 2001, pp. 2250-2251, Amberg et al. 2013, pp. 4 - 15).

Stressor: Climate change
Exposure:
Response:
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Understanding the effects of climate change on freshwater mussels is of crucial importance, because the extreme fragmentation of freshwater drainage systems, coupled with the limited ability of mussels to migrate, will make it particularly difficult for mussels to adjust their range in response to changes in climate (Strayer 2008, p. 30). For example, changes in temperature and precipitation can increase the likelihood of flooding or increase drought duration and intensity, resulting in direct impacts to freshwater mussels (Hastie et al. 2003, pp. 40 - 43, Golladay et al. 2004, p. 503). Riverine mussel distribution appears to be highly dependent on complex hydrological characteristics (e.g., Morales et al. 2006, pp. 669 - 673, Zigler et al. 2008, p. 358).Climate change currently represents a non-imminent threat that may become a future threat of high magnitude to the spectaclecase due to the limited ability of their fragmented populations to migrate. Another study used spectaclecase as a model species to investigate the effects of climate change on population connectivity (Inoue 2017, pp. 2-3). Spectaclecase was chosen because a majority of its extant populations are panmictic (random mating within a breeding population). The study combined ecological niche models with population genetic simulations to examine the effects of two climate change scenarios (RCP2.6 and RCP8.5 scenarios, IPCC 2013) on population connectivity and genetic diversity of spectaclecase (Inoue 2017, p. 4). Simulations indicated that climate change under both scenarios would significantly reduce genetic diversity and connectivity due to loss of suitable habitat (based on precipitation, maximum temperature, diurnal temperature, and flow accumulation) across populations (Inoue 2017, p. 8). Results suggest that a single, large population of spectaclecase in the Mississippi Basin will become fragmented into smaller populations. It is predicted that each of these smaller populations will then begin to differentiate genetically due to isolation (Inoue 2017, p. 8). (USFWS, 2019)

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
Not available

Recovery Actions:

- Establish long-term monitoring of spectaclecase populations with associated habitat characteristics and conditions.
- Continue to develop and implement technology for maintaining and propagating the spectaclecase in captivity. Develop a reintroduction and augmentation plan for the species and assess the feasibility of augmenting existing populations and reintroducing these species into restored habitats in their historic range.

- Conduct research on the life history and genetics of the spectaclecase and apply the results toward management and recovery actions for the species.
- Encourage and support community based watershed stewardship planning and action.
- Develop and implement programs to educate the public and private industry on the need and benefits of ecosystem management, and involve the public in watershed stewardship and conservation efforts for the spectaclecase.
- Protect habitat integrity and quality of river segments that currently support or could support the species.
- Utilize section 7(a)(1) and 7(a)(2) of the Endangered Species Act as mechanisms for conservation of the spectaclecase.
- Investigate the extent of sedimentation, pollution, impoundments, dams and other threats to the species. Examine the sensitivity of the species to various pollutants, sedimentation and apply the results toward management and protection of the species.
- Monitor exotic invasive species and investigate possible control measures for exotic invasive species.
- Inventory and monitoring: The states of Alabama, Arkansas, Illinois, Iowa, Kentucky, Minnesota, Missouri, Tennessee, West Virginia, Wisconsin and Virginia have in the past or are continuing to inventory and monitor mussel populations, including the spectaclecase. Additional information on species occurrences arises from site-specific surveys, typically to fulfill requirements for Section 7 consultations or FERC projects.
- Host research: Several researchers have anticipated the potential need for propagation, and have been attempting to determine the host(s) for the spectaclecase. The host(s) remain unknown, although over 60 species of fish, amphibians, and crayfish have been tested in the lab during host suitability studies (Knudsen and Hove 1997, p. 2, Lee and Hove 1997, pp. 9 - 10, Hove et al. 1998, pp. 13 - 14, Baird 2000, pp. 23 - 24, Henley and Neves 2006, p. 3, Hove et al. 2008, p. 4, Hove et al. 2009, pp. 22 - 23). Further research is needed to determine the host, as that knowledge is a crucial step in potential propagation efforts.
- Genetics research: Several researchers have foreseen the need to increase our understanding of spectaclecase population genetics in order to inform population augmentation and reintroduction efforts and to help determine population viability. Thus, a few studies have initiated investigations of spectaclecase genetics (i.e., Monroe et al. 2007, Elderkin 2009, Inoue et al. 2011) and at least four other studies are underway; one focused on Missouri populations, another focused on the Clinch River and the St. Croix River populations, one focused on the Ouachita River population and a fourth study focused on a Green River population as part of the CRI project discussed above (Miami University of Ohio, D. Berg, principal investigator). Inoue et al. (2011) developed and characterized at least 17 polymorphic loci which indicates that a high-level resolution of genetic structure within and among extant spectaclecase populations can be developed and that estimates of population parameters such as gene flow, effective population size, etc. are likely to be robust.
- Habitat Restoration and Protection: Numerous parcels of public land (e.g., state parks, state forests, wildlife management areas) occur along historical and extant streams of occurrence for the spectaclecase or in their respective watersheds. The Nature Conservancy (TNC) has created bio-reserves along two stream systems harboring extant populations of the spectaclecase: the upper Clinch/Powell River, Tennessee and Virginia; and upper Green River, Kentucky. Numerous public lands occur in the St. Croix watershed in Minnesota and Wisconsin, and the St. Croix River spectaclecase population receives protection by being located in the St. Croix National Scenic River (SCNSR). In addition, several State public lands

(e.g., Chengwatana, Governor Knowles, St. Croix State Forests; Minnesota Interstate, St. Croix, St. Croix Wild River, William O'Brien, Wisconsin Interstate State Parks; St. Croix Islands Wildlife Area; Rock Creek Wildlife Management Area) lie adjacent to some sections of the SCNSR providing additional buffering lands along the St. Croix. The Upper Mississippi River National Wildlife and Fish Refuge manages scores of islands and shoreline acreage throughout a significant portion of the upper Mississippi. In-holdings of the refuge extend from the mouth of the Chippewa River downstream to Muscatine, Iowa. Between Muscatine and Keithsburg, Illinois, the Mark Twain National Wildlife Refuge (MTNWR), Keithsburg Division, has numerous in-holdings. A small disjunct portion of MTNWR, the Gardner Division, occurs in the Canton and La Grange, Missouri, area. Segments of the lower Big Piney River and substantial reaches of the upper Gasconade River flow adjacent or through the Mark Twain National Forest; the lower Big Piney also flows through Ft. Leonard Wood Military Reservation. Small units of public land along the Meramec River include Meramec, Pacific Palisades, and River Round Conservation Areas; and Meramec, Onandaga Cave, and Robertsville State Parks. Several Federal programs, such as Wildlife Habitat Incentives Program and the Environmental Quality Incentives Program, emphasize stream habitat restoration and are being implemented by agency partners (e.g., NRCS-WV). Water quality and habitat improvement projects brought to fruition through these conservation practices are important conservation tools and may aid species recovery. American Rivers has a record of advocacy and action regarding dam removal, river restoration and water quality improvement.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Develop a recovery plan for the species. Perform surveys in known streams to assess the status of known populations and search for additional populations in appropriate habitat to evaluate their potential role in the recovery strategy. Develop a propagation and reintroduction plan. Develop a genetics management plan to inform recovery efforts. Continue to develop and refine the technology and protocols for rearing juveniles in captivity using host fish and in-vitro techniques for future augmentation and reintroductions. Investigate potential sites for future augmentation or reintroduction of captivity reared juveniles and/or adults, including criteria such as suitable habitat, water quality, presence of fish host, and absence of significant threats. Maintain and increase vegetated riparian buffers of streams throughout the range of the species. Initiate watershed-level, community based riparian habitat restoration projects in rivers with spectaclecase or upstream in the watersheds harboring the spectaclecase. Where current numerical criteria of certain pollutants may not be protective of the spectaclecase and other mussels, these standards should be adjusted to better conserve mussel resources. A monitoring program should be developed and implemented to evaluate efforts and to monitor population parameters and habitat conditions. Assess the long-term viability of extant, newly discovered spectaclecase populations, and any populations that may result from reintroductions or be supplemented by augmentations. Monitor invasive species (e.g., zebra mussels) and continue to investigate invasive species control measures. Investigate the extent of impoundments, dams, pollutants, and sedimentation to the spectaclecase and investigate the species sensitivity to those threats. (USFWS, 2019).
- Conservation Measures: The removal of Lock and Dam 6 on the Green River in Kentucky in 2017 may provide additional habitat for the spectaclecase to occupy (L. Koch, USFWS, 2018 pers. comm.) and will likely support the migratory habits of its Hiodon hosts (Hilton et al., 2014). As part of the mitigation for I-74 bridge replacement over the Mississippi River, the Iowa Department of Transportation is coordinating with Iowa Department of Natural Resources to develop artificial

structures (Spectaclecase “motels”) that will be placed in areas with otherwise good habitat to encourage inhabitation (H. Dunn, EcoAnaylsts, Inc., 2018, pers. comm.). Some individuals were moved to a different location nearby as a result of the bridge replacement. The Service is cooperating with state, federal, and local agencies, universities, and other partners to develop and implement a propagation and reintroduction plan for this species in order to comply with the Service’s controlled propagation policy. As such, we are using International Conservation of Nature (IUCN) guidelines to facilitate our assessment of ecological, social, and economic risks, and to aid development of collection, release, and monitoring strategies. The propagation and reintroduction plan is still in development. Reintroducing populations to former parts of its historical range will add redundancy by adding new populations and will help to mediate the effects of habitat fragmentation. Diversifying to new locations may also help mediate effects of zebra mussels, particularly if reintroductions take place in areas where the threat of zebra mussels or other invasive species are low. Augmenting existing populations will make populations more resilient to stochastic events and may help address the threat of small population genetics. (USFWS, 2019)

References

Final listing rule

recovery outline January 2014 USFWS, 2019. Spectaclecase (Cumberlandia monodonta) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region. Minnesota/Wisconsin Ecological Services Field Office Bloomington, Minnesota. 19 pp.

recovery outline January 2014. USFWS, 2019. Spectaclecase (Cumberlandia monodonta) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region. Minnesota/Wisconsin Ecological Services Field Office Bloomington, Minnesota. 19 pp.

recovery outline January 2015

recovery outline January 2014

USFWS, 2019. Spectaclecase (Cumberlandia monodonta) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region. Minnesota/Wisconsin Ecological Services Field Office Bloomington, Minnesota. 19 pp.

SPECIES ACCOUNT: *Cyclonaias necki* (Guadalupe Orb)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Guadalupe orb occurs only in the Guadalupe Basin and is a small-sized mussel with a shell length that reaches up to 2.5 in (63 mm) (Burlakova et al. 2018, p. 48). Guadalupe orb shells are thinner and more compressed but otherwise morphologically similar to the closely related Texas pimpleback. The posterior ridge is more distinct and prominent, and the umbo is more compressed than in Texas pimpleback (Burlakova et al. 2018, p. 48). Individuals collected from the upper Guadalupe River (near Comfort, Texas) averaged 1.9 in (48 mm) (Bonner et al. 2018, p. 221) (USFWS, 2024a).

Taxonomy

Burlakova et al. (2018, entire) recently described the Guadalupe orb (Cyclonaias necki) from the Guadalupe River Basin as a separate species distinct from Texas pimpleback. The Guadalupe orb occurs only in the Guadalupe Basin and is a small-sized mussel with a shell length that reaches up to 2.5 in (63 mm) (Burlakova et al. 2018, p. 48). Guadalupe orb shells are thinner and more compressed but otherwise morphologically similar to the closely related Texas pimpleback. The posterior ridge is more distinct and prominent, and the umbo is more compressed than in Texas pimpleback (USFWS, 2024a)

Historical Range

Guadalupe Orb historically occurred throughout the length of the Guadalupe and Blanco Rivers within the Guadalupe River basin (Horne and McIntosh 1979, p. 122; Howells 2010, p. 26; Randklev et al. 2017, pp. 109-110; Figure 3). In the Guadalupe River, the species ranged from Comal, Guadalupe, Kendall, Kerr, and Victoria Counties (USFWS, 2024).

Current Range

There are two remaining populations of the Guadalupe Orb, one in the upper Guadalupe River and one in the San Marcos and lower Guadalupe River (Figure 3). Historically, populations throughout the basin were likely connected by fish migration, but due to impoundments and low water conditions, the two remaining populations are isolated from one another, and repopulation of extirpated locations is unlikely to occur without human assistance. The upper Guadalupe River population is in unhealthy condition (USFWS 2022, pp. 124-131). The Lower Guadalupe River population, which also extends into the San Marcos River, is in moderate condition (USFWS, 2024).

Critical Habitat Designated

Yes; 7/5/2024.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli), and threatened species status for the Texas fawnsfoot (Truncilla macrodon), seven species of freshwater mussels from central Texas. We also issue a rule under section 4(d) of the Act for the Texas fawnsfoot that provides measures that are necessary and advisable to provide for the conservation of the Texas fawnsfoot. In addition, we designate critical habitat for all seven species. In total, approximately 1,577.5 river miles (2,538.7 river kilometers) in Blanco, Brown, Caldwell, Coleman, Comal, Concho, DeWitt, Gillespie, Gonzales, Guadalupe, Hays, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, Palo Pinto, Parker, Runnels, San Saba, Shackelford, Stephens, Sutton, Throckmorton, Tom Green, Travis, and Victoria Counties, Texas, fall within the boundaries of the critical habitat designation. This rule applies the protections of the Act to these species and their designated critical habitat (89 FR, 48034)

Critical Habitat Designation

We have determined that the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli) meet the Act's definition of endangered species, and the Texas fawnsfoot (Truncilla macrodon) meets the Act's definition of a threatened species; therefore, we are listing them as such, finalizing a rule under section 4(d) of the Act for the Texas fawnsfoot, and designating critical habitat. Both listing a species as an endangered or threatened species and designating critical habitat can be completed only by issuing a rule through the Administrative Procedure Act rulemaking process (5 U.S.C. 551 et seq.). What this document does. This rule makes final the listing of the Guadalupe fatmucket, Texas fatmucket, Guadalupe orb, Texas pimpleback, Balcones spike, and false spike as endangered species, and the Texas fawnsfoot as a threatened species with a rule issued under section 4(d) of the Act (a ''4(d) rule''). In addition, this rule designates critical habitat for all seven central Texas mussel species in 20 units (including 32 subunits) totaling 1,577.5 river miles (2,538.7 river kilometers (km)) on private, State, and Federal property within portions of 31 counties in Texas (89 FR, 48034)

Unit GORB–1: Upper Guadalupe River; Comal, Kendall, and Kerr Counties, Texas. (i) Unit GORB–1 consists of two subunits: (A) Subunit GORB–1a (South Fork Guadalupe River) consists of 5.1 river miles (mi) (8.2 kilometers (km)) in Kerr County, Texas. All of the riparian lands that border this unit are in private ownership. (B) Subunit GORB–1b (Upper Guadalupe River) consists of 97.1 river mi (156.3 km) of the Guadalupe River in Comal, Kendall, and Kerr Counties, Texas. The riparian lands that border this subunit are in State/local government (5 percent) and private (95 percent) ownership. (ii) Unit GORB–1 includes stream channel up to bankfull height.

Unit GORB–2: Lower Guadalupe River; Caldwell, DeWitt, Gonzales, Guadalupe, and Victoria Counties, Texas. (i) Unit GORB–2 consists of two subunits: (A) Subunit GORB–2a (San Marcos River) consists of 63.9 river mi (102.8 km) in Caldwell, Gonzales, and Guadalupe Counties, Texas. The riparian lands that border this subunit are in State/local government (6 percent) and private (94 percent) ownership. (B) Subunit GORB–2b (Lower Guadalupe River) consists of 122.4 river mi (197.0 km) in DeWitt, Gonzales, and Victoria Counties, Texas. The riparian lands that border this subunit are in State/local government (5 percent) and private (95 percent) ownership. (ii) Unit GORB–2 includes stream channel up to bankfull height.

Primary Constituent Elements/Physical or Biological Features

(i) Flowing water at rates suitable to keep riffle habitats wetted and welloxygenated and to prevent excess sedimentation or scour during high-flow events but not so high as to dislodge individuals;

(ii) Stable riffles and runs with substrate composed of cobble, gravel, and fine sediments

(iii) Channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis olivaris), and tadpole madtom (Noturus gyrinus) present

(iv) Water quality parameters within the following ranges: (A) Dissolved oxygen greater than 2 milligrams per liter (mg/L); (B) Salinity less than 2 parts per thousand; (C) Total ammonia less than 0.77 mg/ L total ammonia nitrogen; (D) Water temperature below 29 °C (84.2 °F); and (E) Low levels of contaminants

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the central Texas mussels may require special management considerations or protections to reduce the following threats: increased fine sediment, changes in water quality, altered hydrology from both inundation and flow loss/scour, predation and collection, and barriers to fish movement. Management activities that could ameliorate these threats include, but are not limited to: Use of best management practices (BMPs) designed to reduce sedimentation, erosion, and bank side destruction; protection of riparian corridors and retention of sufficient canopy cover along banks; exclusion of livestock and nuisance wildlife (feral hogs, exotic ungulates); moderation of surface and groundwater withdrawals to maintain natural flow regimes; increased use of stormwater management and reduction of stormwater flows into the systems; use of highest water quality standards for wastewater and other return flows; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the occupied areas we are designating as critical habitat contain the PBFs that are essential to the conservation of the species and that may require special management considerations or protection. Special management considerations or protection may be required of the Federal action agency to eliminate, or to reduce to negligible levels, the threats affecting the PBFs of each unit (89 FR, 48034)..

Life History

Food/Nutrient Resources

Food Source

Adult: detritus/phytoplankton

Lifespan

Adult: 15-72 years (USFWS, 2022)

Dependency on Other Individuals or Species

Adult: Host fish. Recent laboratory studies conclude that channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis olivaris), Yellow bullhead (Amerius natalis), and tadpole madtom (Noturus gyrinus) are suitable host fishes for Guadalupe orb from a total of 12 species tested (USFWS, 2022).

Key Resources Needed for Breeding

Adult: Host fish. Recent laboratory studies conclude that channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis olivaris), Yellow bullhead (Amerius natalis), and tadpole madtom (Noturus gyrinus) are suitable host fishes for Guadalupe orb from a total of 12 species tested (USFWS, 2022).

Reproduction Narrative

Adult: Reproduction and fish host interaction information for the Guadalupe orb is assumed to be similar to that of the Texas pimpleback provided above (section 2.B.5.c). Recent laboratory studies conclude that channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis olivaris), Yellow bullhead (Amerius natalis), and tadpole madtom (Noturus gyrinus) are suitable host fishes for Guadalupe orb from a total of 12 species tested (Dudding et al. 2019, p. 15). Dudding et al. (2019) cautioned that the apparent clumped distribution of Guadalupe orb (and congeners) in “strongholds” could be related to observed ongoing declines in native catfishes, including the small and rare tadpole madtom, a riffle-specialist (USFWS, 2022).

Habitat Type

Adult: Rivers

Habitat Narrative

Adult: occurs in medium- to large-sized streams and rivers in flowing waters with “mud, sand, or gravel bottoms, or sometimes in gravel-filled cracks in the bedrock, often at depths less than 2 m” and are “not known from impoundments” (Howells 2014, p. 93). They are also found in riffle and run mesohabitats with flowing water (Randklev et al. 2017c, p. 110) (Table 2.6) and have a particular affinity for riffles compared with other mussel species in the Lower Colorado River (Bonner et al. 2018, p. 244). Habitat suitability for Texas pimpleback in the Lower Colorado River (near Altair, Texas) was reported to be highest at water depths of 0.6 to 0.9 m, with mean column velocities below 0.2 m/s (Bonner et al. 2018, pp. 243, 251) (USFWS, 2022).

Dispersal/Migration

Population Information and Trends

Resiliency:

The Guadalupe orb is known to currently occur in the Guadalupe River basin. Currently, there are two known populations. One is in unhealthy condition in the upper Guadalupe River. The Lower Guadalupe River population, which also extends into the San Marcos River, is in moderate condition (USFWS, 2022).

Representation:

We consider the Guadalupe orb to have representation in only one river basin (USFWS, 2022).

Redundancy:

Within these identified representation areas, the Guadalupe orb has only two populations in the Guadalupe River basin. Therefore, the species exhibits low redundancy (USFWS, 2022).

Number of Populations:
2 populations (USFWS, 2022)

Population Size:
10 live specimens found in each population. More are likely (USFWS< 2022).

Population Narrative:
Guadalupe orb is known from the Guadalupe River basin. Given the presumed historical distribution of the species, the Guadalupe orb currently occupies about 54% of its potential historical range. The Guadalupe orb is currently found in 276 river miles of a presumed historical range of 506 stream miles. This approximate range reduction assumes the species continuously occupied its entire historical range, which is unlikely given the species' specialized habitat preferences. Two populations of the Guadalupe orb are known: one in unhealthy condition in the upper reaches of the Guadalupe River and another in moderate condition in the lower Guadalupe River, which also extends upstream into the San Marcos Rivers (USFWS, 2022).

Threats and Stressors

Stressor: Increased fine sediment (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Juvenile and adult Central Texas mussels inhabit microsites that have abundant interstitial spaces, or small openings in an otherwise closed matrix of substrate, created by gravel, cobble, boulders, bedrock crevices, tree roots, and other vegetation, with some amount of fine sediment (i.e., clay and silt) necessary to provide appropriate shelter. However, excessive amounts of fine sediments can reduce the number of appropriate microsites in an otherwise suitable mussel bed by filling in these interstitial spaces and can smother mussels in place. Central Texas mussels generally require stable substrates, and loose silt deposits do not generally provide for substrate stability. Interstitial spaces provide essential habitat for juvenile mussels. Juvenile freshwater mussels burrow into interstitial substrates, making them particularly susceptible to degradation of this habitat feature. When clogged with sand or silt, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability. While adult mussels can be physically buried by excessive sediment, "the main impacts of excess sedimentation on unionids are often sublethal" and include interference with feeding mediated by valve closure (Brim Box and Mossa 1999, p. 101). Many land use activities can result in excessive erosion, sediment production and channel instability; including, but not limited to, logging, crop farming, ranching, mining, and urbanization (USFWS, 2022).

Stressor: Changes in water quality
Exposure:
Response:
Consequence:
Narrative: Above all else, freshwater mussels require water in sufficient quantity and quality on a consistent basis to complete their life cycles and those of their host fish. Urban growth and other

anthropogenic activities across Texas are placing increased demands on limited water supplies that in turn, can have deleterious effects on water quality. Water quality can be degraded through contamination or alteration of water chemistry. Chemical contaminants are ubiquitous throughout the environment and are a major reason for the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Chemicals enter the environment through both point and nonpoint source discharges, including hazardous spills, industrial wastewater, municipal effluents, and agricultural runoff. These sources contribute organic compounds, trace metals, pesticides, and a wide variety of newly emerging contaminants (e.g., pharmaceuticals) that comprise some 85,000 chemicals in commerce today that are released to the aquatic environment (EPA 2018, p. 1). The extent to which environmental contaminants adversely affect aquatic biota can vary depending on many variables such as concentration, volume, and timing of the release, but species diversity and abundance consistently ranks lower in waters that are known to be polluted or otherwise impaired by contaminants. Freshwater mussels are not generally found for many miles downstream of municipal wastewater treatment plants (Gillis et al. 2017, p. 460; Goudreau et al. 1993, p. 211; Horne and McIntosh, p. 119). For example, transplanted common freshwater mussels (Amblema plicata and Corbicula fluminea) showed reduced growth and survival below a wastewater treatment plant (WWTP) outfall relative to sites located upstream of the WWTP in Wilbager Creek (a tributary to the Colorado River in Travis County, Texas). Water chemistry was altered by the wastewater flows at downstream sites, with elevated constituents in the water column that included copper, potassium, magnesium, and zinc (Nobles and Zhang 2015, p.11; Duncan and Nobles 2012, p. 8). Contaminants released during hazardous spills are also of concern. Although spills are relatively short-term events and may be localized, depending on the types of substances and volume released, water resources nearby can be severely impacted and degraded for years after the incident (USFWS, 2022).

Stressor: Altered Hydrology – Inundation
Exposure:
Response:
Consequence:
Narrative: Central Texas mussels are adapted to flowing water (lotic habitats) rather than standing water (lentic habitats) and require free-flowing water to survive. Low flow events (including stream drying) and inundation can eliminate appropriate habitat for Central Texas mussels, and while these species can survive these events for a very short duration, populations that experience prolonged drying events or repeated drying events will not persist. Inundation has primarily occurred upstream of dams, both large (such as the Highland Lakes and other major flood control and water supply reservoirs) and small (low water crossings and diversion dams typical of the tributaries and occurring usually on privately owned lands). Inundation causes an increase in sediment deposition, eliminating the crevices that many Central Texas mussel species inhabit. Inundation also includes the effects of reservoir releases where frequent variation in surface water elevation acts to make habitats unsuitable for Central Texas mussels. In large reservoirs, deep water is very cold and often devoid of oxygen and necessary nutrients. Cold water (less than 11 °Celsius (C) or 52 °Fahrenheit (F)) has been shown to stunt mussel growth and delay or hinder spawning. The Central Texas mussels are not known to tolerate inundation under large reservoirs. Further, deep water reservoirs with bottom release (like Canyon Reservoir, which supports a recreational rainbow and brown trout fishery) can affect water temperatures several miles downriver. The water temperature remains below 21.1°C for the first 6.3-km (3.9 miles) of the 22.2-km (13.8 miles) Canyon Reservoir tailrace (USFWS, 2022).

Stressor: Altered Hydrology – Flow Loss and Scour
Exposure:
Response:
Consequence:
Narrative: Very low water levels are detrimental to Central Texas mussel populations as well. Droughts that have occurred in the recent past have led to extremely low flows in several Central Texas rivers. Many of these rivers have some resiliency to drought because they are spring fed (Colorado tributaries, Guadalupe), are very large (lower Brazos and Colorado), or have significant return flows (Trinity) but drought in combination with increased groundwater pumping may lead to lower river flows of longer duration than have been recorded in the past. Reservoir releases can be managed to some extent during drought conditions to prevent complete dewatering below many major reservoirs (USFWS, 2022).

Stressor: Predation, Collection, Disease, and Invasive Species
Exposure:
Response:
Consequence:
Narrative: Predation on freshwater mussels is a natural ecological interaction. Raccoons, snapping turtles, and fish are known to prey upon Central Texas mussels. Under natural conditions, the level of predation occurring within Central Texas mussel populations is not likely to pose a significant risk to any given population. However, during periods of low flow, terrestrial predators have increased access to portions of the river that are otherwise too deep under normal flow conditions. High levels of predation during drought have been observed on the Llano and San Saba rivers. As drought and low flow are predicted to occur more often and for longer periods due to the effects of future climate change, the Hill Country tributaries (of the Colorado River) in particular are expected to experience additional predation pressure into the future, and this may become especially problematic in the Llano and San Saba Rivers. Predation is expected to be less of a problem for the lower portions of the main stem river populations, as the rivers are significantly larger than the tributary streams and Central Texas mussels are thus less likely to be found in exposed or very shallow habitats (USFWS, 2022).

Stressor: Barriers to fish movement
Exposure:
Response:
Consequence:
Narrative: Central Texas mussels historically colonized new areas through movement of infested host fish, as newly metamorphosed juveniles would excyst from host fish in new locations. Today, the remaining Central Texas mussel populations are significantly isolated from one another by major reservoirs such that recolonization of areas previously extirpated is extremely unlikely if not impossible due to existing contemporary barriers to host fish movement. There is currently no opportunity for interaction among any of the extant Central Texas mussel populations as they are all fragmented from one another by reservoirs. The overall distribution of mussels is, in part, a function of the dispersal of their host fish. There is limited potential for immigration between populations other than through the attached glochidia being transported to a new area or to another population. Small populations are more affected by this limited immigration potential because they are susceptible to genetic drift, resulting from random loss of genetic diversity, and inbreeding depression. At the species level, populations that are eliminated

due to stochastic events cannot be recolonized naturally, leading to reduced overall redundancy and representation (USFWS, 2022).

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Climate change has been documented as has already taken place, and continued greenhouse gas emissions at or above current rates will cause further warming (Intergovernmental Panel on Climate Change (IPCC) 2013, pp. 11-12). Warming in Texas is expected to be greatest in the summer (Maloney et al. 2014, p. 2236, Fig. 3). In Texas, the number of extremely hot days (high temperatures exceeding 95º Fahrenheit) is expected to double by around 2050 (Kinniburgh et al. 2015, p. 83). West Texas is an area expected to show greater responsiveness to the effects of climate change (Diffenbaugh et al. 2008, p. 3). Changes in stream temperatures are expected to reflect changes in air temperature, at a rate of approximately 0.6 – 0.8°C increase in stream water temperature for every 1°C increase in air temperature (Morrill et al. 2005, pp. 1-2, 15) and with implications for temperature-dependent water quality parameters such as DO and ammonia toxicity. Given that the Central Texas mussels exist at or near the ecophysiogical edge of climate and habitat gradients of unionid biogeography in North America, it is likely that they may be particularly vulnerable to future climate changes in combination with current and future stressors (USFWS, 2022).

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2024. Central Texas Mussels Recovery Outline. Austin Texas ESFO (lead)

Texas Coastal and Central Plains ESFO. 30 pp. Found online on June 25, 2024 at https://ecos.fws.gov/docs/recovery_plan/Recovery%20Outline%20CTX%20Mussels%2012June2024%20Signed.pdf USFWS. 2024a. FR Vol. 89, No. 108 Pages 48034-48130. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, Balcones Spike, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. Final Rule.

89 FR. No. 108. Pages 48034-48130. Endangered and Threatened Wildlife and Plants

USFWS. 2022. Species Status Assessment Report for the Central Texas Mussels: False spike (Fusconaia mitchelli) Balcones spike (Fusconaia iheringi) Texas fatmucket (Lampsilis bracteata) Texas fawnsfoot (Truncilla macrodon) Texas pimpleback (Cyclonaias petrina) Guadalupe fatmucket (Lampsilis bergmanni) Guadalupe orb (Cyclonaias necki). Version 2.1. USFWS. Region 2. Albuquerque, NM.

USFWS. 2022. Species status assessment report for the Central Texas Mussels, Version 2.1. September 2022. Albuquerque, NM.

SPECIES ACCOUNT: *Cyprogenia aberti* (Western fanshell)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

Fanshell mussels have a thick, compressed to moderately inflated, round to triangular shell (up to 3 inches (76 millimeters)). The posterior ridge is prominent and raised with a shallow sulcus from umbo to middle of the ventral margin. Periostracum is a dull tan with a distinctive ray pattern from bands of tiny pigment flecks. The shell has a wrinkled or rough appearance. The pseudocardinal teeth are large and lateral teeth short and slightly curved. The beak cavity is moderately deep with somewhat pointed beaks extending slightly above the hinge line. The nacre is white (USFWS, 2022).

Taxonomy

PHYLUM Mollusca Linnaeus, 1758 CLASS Bivalvia Linnaeus, 1758 ORDER Unionida Gray, 1854 FAMILY Unionidae Rafinesque, 1820 SUBFAMILY Ambleminae Rafinesque, 1820 TRIBE Lampsilini Ihering, 190

Historical Range

The Western Fanshell has a historical range comprising multiple rivers within the Neosho-Verdigris, lower Arkansas, Lower Mississippi–St. Francis, and upper White river drainages of Arkansas, Missouri, Kansas, and Oklahoma. There are reported records from archeological sites within four river basins in Mississippi. Mississippi recognizes Western Fanshell and ranks it as presumed extirpated, but because of the genetic uncertainties of Cyprogenia and the lack of live individuals, we do not include these records within the Western Fanshell historical range for this SSA report. The historical range of “Ouachita” Fanshell comprises multiple rivers within the Ouachita River basin in southern Arkansas and northern Louisiana (USFWS, 2022).

Current Range

Western Fanshell currently occupies 11 of 26 historical management units, and “Ouachita” Fanshell occupies four of five historical management units. Forty-five percent of the Western Fanshell management units (MUs) are currently in low condition (i.e., are predominantly composed of populations that are small with no evidence of recruitment or age class structure). Fifty percent of “Ouachita” Fanshell MUs are in low condition. The Western Fanshell and “Ouachita” Fanshell also have suffered a 60% and 47% reduction in stream length occupation, respectively (USFWS, 2022).

Critical Habitat Designated

Yes; 7/27/2023.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine threatened species status under the Endangered Species Act of 1973 (Act), as amended, for the western fanshell (Cyprogenia aberti), a freshwater mussel species from Arkansas, Kansas, Missouri, and Oklahoma, and the ‘‘Ouachita’’ fanshell (Cyprogenia cf. aberti), a freshwater mussel species from Arkansas and Louisiana. We also designate critical habitat for both species. In total, approximately 261.4 river miles (420.7 kilometers) in Arkansas and Missouri fall within the boundaries of the critical habitat designation for western fanshell. In total, approximately 227.7 river miles (366.5 kilometers) in Arkansas fall within the boundaries of the critical habitat designation for ‘‘Ouachita’’ fanshell. In addition, we finalize a rule under the authority of section 4(d) of the Act that provides measures that are necessary and advisable to provide for the conservation of these species. This rule extends the Act’s protections to these species and their designated critical habitats.

Critical Habitat Designation

Critical habitat units are depicted for Fulton, Independence, Jackson, Lawrence, Randolph, and Sharp Counties, Arkansas, and Butler, Jasper, Madison, and Wayne Counties, Missouri

Unit WF 1: Upper Black River; Butler and Wayne Counties, Missouri. (i) Unit WF 1 consists of 64.7 river miles (mi) (104.1 kilometers (km)) of Black River in Butler and Wayne Counties, Missouri, from Clearwater Dam southwest of Piedmont, Wayne County, extending downstream to Butler County Road 658 crossing southeast of Poplar Bluff, Butler County. Unit WF 1 includes the river channel up to the ordinary high water mark. Riparian lands that border the unit include approximately 51 river mi (82.1 km; 79 percent) in private ownership and 13.7 river mi (22 km; 21 percent) in public (Federal or State) ownership. Approximately 2.7 miles of the public ownership in this unit are State lands associated with Missouri Department of Conservation’s (MDC) Bradley A. Hammer Memorial Conservation Area, Dan River Access, Hilliard Access, and Stephen J. Sun Conservation Area. Eleven miles are Federal land associated with the U.S. Forest Service’s (USFS) Mark Twain National Forest and U.S. Army Corps of Engineers’ Clearwater Recreation Area.

Unit WF 2: Lower Black/ Strawberry River; Independence, Jackson, Lawrence, and Sharp Counties, Arkansas. (i) Unit WF 2 consists of 111.3 river mi (179.1 km) of Black River and Strawberry River in Independence, Jackson, Lawrence, and Sharp Counties in Arkansas. Unit WF 2 includes the river channel up to the ordinary high water mark. Black River makes up 54.6 river mi (87.9 km) from the mouth of Spring River northeast of Black Rock, extending downstream to the mouth of Strawberry River northeast of Dowdy, Independence County. Strawberry River makes up 56.7 river mi (91.2 km) from the mouth of Lave Creek north of Evening Shade, Sharp County, extending downstream to the confluence with Black River northeast of Dowdy, Independence County. Riparian lands that border the unit include approximately 100.4 river mi (161.6 km; 90 percent) in private ownership and 10.9 river mi (17.5 km; 10 percent) in public (State) ownership. The public land ownership in this unit is associated with Arkansas Game and Fish Commission’s Shirey Bay Rainey Brake Wildlife Management Area on Black River. The Nature Conservancy’s Strawberry River Preserve and Ranch on Strawberry River is also in this unit.

Units WF 3 and WF 4 have been excluded from this critical habitat designation. (9) Unit WF 5: St. Francis River; Madison and Wayne Counties, Missouri. (i) Unit WF 5 consists of 49.3 river mi (79.3 km) of St. Francis River in Madison and Wayne Counties, Missouri, extending from the mouth of Wachita Creek west of Fredericktown, Madison County, downstream to the mouth of Big Creek northwest of Silva, Wayne County. Unit WF 5 includes the river channel up to the ordinary high water mark. Riparian lands that border the unit include approximately 36.7 river mi (59.1 km; 74 percent) in private ownership and 12.6 river mi (20.2 km; 26 percent) in public (Federal or State) ownership. Approximately 2.4 river mi of the public ownership in this unit are State lands associated with MDC’s Coldwater Conservation Area, Mill Stream Gardens, and Roselle Access.

Ten miles are Federal land associated with the USFS's Mark Twain National Forest.

Unit WF 6: South Fork Spring River; Fulton County, Arkansas. (i) Unit WF 6 consists of 13.4 river mi (21.6 km) of South Fork Spring River in Fulton County, Arkansas, from the mouth of Camp Creek east of Salem, Fulton County, extending downstream to the Arkansas Highway 289 crossing northwest of Cherokee Village, Fulton County. Unit WF 6 includes the river channel up to the ordinary high water mark. Approximately 100 percent of the riparian lands that border the unit are in private ownership.

Unit WF 7: Spring River (AR); Lawrence and Randolph Counties, Arkansas. (i) Unit WF 7 consists of 14.2 river mi (22.9 km) of Spring River in Lawrence and Randolph Counties, Arkansas, from the mouth of Wells Creek at Ravenden, extending downstream to the mouth of Stennitt Creek southeast of Imboden, Lawrence County. Unit WF 7 includes the river channel up to the ordinary high water mark. Approximately 100 percent of the riparian lands that border the unit are in private ownership.

Unit WF 8: Spring River (MO); Jasper County, Missouri. (i) Unit WF 8 consists of 8.5 river mi (13.7 km) of Spring River in Jasper County, Missouri, from the mouth of North Fork Spring River east of Asbury, Jasper County, Missouri, extending downstream to the Kansas State line, then from where it reenters Missouri to the mouth of Center Creek west of Carl Junction, Jasper County, Missouri. Unit WF 8 includes the river channel up to the ordinary high water mark. Approximately 100 percent of the riparian lands that border the unit are in private ownership.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of ''Ouachita'' fanshell consist of the following components:

(i) Adequate flows, or a hydrologic flow regime (magnitude, timing, frequency, duration, rate of change, and overall seasonality of discharge over time), necessary to maintain benthic habitats where the species is found and to maintain stream connectivity, specifically providing for the exchange of nutrients and sediment for maintenance of the mussel's and fish hosts' habitat and food availability, maintenance of spawning habitat for native host fishes, and the ability for newly transformed juveniles to settle and become established in their habitats. Adequate flows ensure delivery of oxygen, enable reproduction, deliver food to filter-feeding mussels, and reduce contaminants and fine sediments from interstitial spaces.

(ii) Suitable substrates and connected instream habitats, characterized by geomorphically stable stream channels and banks (that is, channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with habitats that support a diversity of freshwater mussel and native fish (such as stable riffle-run-pool habitats that provide flow refuges consisting of siltfree gravel and coarse sand substrates).

(iii) Water and sediment quality necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages, including, but not limited to, dissolved oxygen (generally above 3 parts per million (ppm)) and water temperature (generally below 80 degrees Fahrenheit (°F) (27 degrees Celsius (°C)). Additionally, water and sediment should be low in ammonia (generally below 1.0 ppm total ammonia-nitrogen) and heavy metals, and lack excessive total suspended solids and other pollutants.

(iv) The presence and abundance of fish hosts necessary for recruitment of the ‘‘Ouachita’’ fanshell, including logperch (Percina caprodes), slenderhead darter (Percina phoxocephala), or orangebelly darter (Etheostoma radiosum).

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the western fanshell and ‘‘Ouachita’’ fanshell may require special management considerations or protections to reduce the following threats:

(1) Alteration of the natural flow regime (modifying the natural hydrograph and seasonal flows), including water withdrawals, resulting in flow reduction and available water quantity

(2) urbanization of the landscape, including (but not limited to) land conversion for urban and commercial use, infrastructure (pipelines, roads, bridges, utilities), and urban water uses (resource extraction activities, water supply reservoirs, wastewater treatment, etc.)

(3) significant alteration of water quality and nutrient pollution from a variety of activities, such as industrial and municipal effluents, mining, and agricultural activities

(4) land use activities that remove large areas of forested wetlands and riparian systems

(5) dam construction and culvert and pipe installation that create barriers to movement for the western fanshell and ‘‘Ouachita’’ fanshell, or their host fishes

(6) changes and shifts in seasonal precipitation patterns as a result of climate change

(7) other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. Management activities that could ameliorate these threats include, but are not limited to: Use of best management practices designed to reduce sedimentation, erosion, and bank destruction; protection of riparian corridors and woody vegetation; moderation of surface and ground water withdrawals to maintain natural flow regimes; improved stormwater management; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the occupied areas we are designating as critical habitat contain the physical or biological features that are essential to the conservation of the species and which may require special management considerations or protection. Special management considerations or protection may be required of the Federal action agency to eliminate, or to reduce to negligible levels, the threats affecting the physical and biological features of each unit.

Life History

Food/Nutrient Resources

Food Source

Adult: Like all mussels, the Fanshell mussels are omnivores that primarily filter feed on a wide variety of microscopic particulate matter suspended in the water column, including phytoplankton, zooplankton, bacteria, detritus, and dissolved organic matter (Haag 2012, p.26). Juveniles likely pedal feed in the sediment, whereas adults filter feed from the water column. A recent nutrition study found that probiotic bacteria (Bacillus subtilis) enhanced early juvenile growth and survival (USFWS, 2022).

Food/Nutrient Narrative

Adult: Adults are detritivores. Larvae are parasitic.

Reproductive Strategy

Adult: Bradytictic

Lifespan

Adult: Unknown. The lifespan for the Fanshell mussels is unknown, but Jones and Neves (2002, p.81) aged 84 Cyprogenia stegaria individuals with a range of 6 to 26 years and a mean age at death of 12-13 years (USFWS, 2022).

Dependency on Other Individuals or Species

Adult: Fish hosts. Logperch (Percina caprodes) is a suitable fish host in all river basins (Eckert 2003, pp. 18 – 19). Rainbow Darter (Etheostoma caeruleum) is a good fish host in the St. Francis River, but poor host in the Arkansas River basin (Eckert 2003, p. 19). Slenderhead, Fantail, Rainbow, and Orangebelly darters are suitable hosts only for their respective sympatric Fanshell mussel population (USFWS, 2022).

Breeding Season

Adult: typically spawning from August – October and release conglutinates in early spring (USFWS, 2022).

Other Reproductive Information

Adult: The Fanshell mussels are bradytictic (long-term) brooders typically spawning from August – October and release conglutinates in early spring (Barnhart 1997, p. 13; N. Eckert 2020, pers. comm.). Fanshell mussel conglutinates resemble annelid worms, and this resemblance attracts fish hosts (Eckert and Barnhart 2008, p. 12). Females typically release 12 – 33 conglutinates with a mean number of eggs per conglutinate of 23,056 (Barnhart 1997, p. 10; Eckert 2003, p. 62). Barnhart (1997, p. 10) reports mean fecundity as 93,923 offspring per female per year in the Spring River, Kansas. Eckert's (2003, p. 26) mean fecundity ranged from 63,182 (St. Francis River) to 132,363 (Verdigris River), with a mean of 69,634 offspring per female per year in the Ouachita River. Western Fanshell from the Arkansas River basin tend to be larger with larger conglutinates and thus greater fecundity (Eckert 2003, p. 62). Approximately 85% of the eggs in each conglutinate are sterile, apparently providing a structural role in the conglutinate by providing a tough elastic support. The durable core of sterile eggs also serves to increase handling time by fish hosts and theoretically makes conglutinates more palatable to fish hosts (Barnhart 1997, pp. 6 – 10). The mean number of viable glochidia/conglutinate ranges from 2,803 ± 1,263 (Ouachita) to 5,272 ± 2,306 (St. Francis) (Barnhart 1997, p. 10; Eckert 2003, p. 62). The glochidia of Cyprogenia are "morphologically depressed" because they have a narrow gape and short dorso-ventral height, which makes it difficult to achieve good rates of initial attachment when pipetting glochidia in suspension onto fish gills. Better glochidia attachment onto fish gills occurs when conglutinates are fed upon by the fish (USFWS, 2022).

Reproduction Narrative

Adult: As with most freshwater mussels, the Fanshell mussels have a unique life cycle that relies on fish hosts for successful reproduction (Figure 2.3). Freshwater mussels are generally immobile. They disperse primarily through the behavior of host fish and their tendencies to travel upstream and against the current (positive rheotaxis) in rivers and streams. Mussels are broadcast spawners; males release sperm into the water column, which females take in through the incurrent siphon (the tubular structure used to draw water into the body of the mussel). The sperm fertilizes the eggs, which the female holds until maturation in an area of the gills called the marsupial chamber. The developing larvae remain in the marsupial chamber until they mature and are ready for release as glochidia, to attach on the gills, head, or fins of fishes (Barnhart et al. 2008, pp. 371 – 373; Vaughn and Taylor 1999, p. 913). Glochidia die if they fail to find a host fish, attach to the wrong species of host fish, attach to a fish that has developed immunity from prior infestations, or attach to the wrong location on a host fish (Bogan 1993, p. 599; Neves 1991, p. 254). Glochidia encyst (enclose in a cyst-like structure) on the host's tissue, draw nutrients from the fish, and develop into juvenile mussels weeks or months after attachment (Arey 1932, pp. 214 – 215). The glochidia for the Fanshell mussels remain encysted for about a month until transformation to the juvenile stage (Figure 2.4; Barnhart 1997, p. 12). Once transformed, the juveniles excyst (release) from the fish and drop to the substrate. Freshwater mussel species vary in both onset and duration of spawning, how long developing larvae remain in the marsupial gill chambers, and which fish species serve as hosts. The mechanisms employed by mussel species to increase the likelihood of interaction between host fish and glochidia also vary by species. (USFWS, 2022).

Habitat Type

Adult: Freshwater/benthic (USFWS, 2022)

Habitat Vegetation or Surface Water Classification

Adult: Riverine (USFWS, 2022)

Dependencies on Specific Environmental Elements

Adult: moderate to swift current (USFWS, 2022)

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, deep water, dams

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS, 2022)

Environmental Specificity

Adult: Moderate (inferred from USFWS, 2022)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from USFWS, 2022)

Habitat Narrative

Adult: The Fanshell mussels are typically found in large creeks and rivers with good water quality, moderate to swift current and gravel-sand substrates. Most freshwater mussels, including the Fanshell mussels, occur in aggregations (mussel beds) that vary in size and are often separated by stream reaches where mussels are absent or rare (Vaughn 2012, p. 983). Specific information on microhabitat requirements is lacking. Habitat utilized by Fanshell mussels is not static over time and suitable habitat patches may disappear and re-emerge in different locations (USFWS, 2022).

Dispersal/Migration

Motility/Mobility

Adult: Low

Dispersal

Adult: Low-moderate (inferred from USFWS, 2022)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish

Dispersal/Migration Narrative

Adult: They disperse primarily through the behavior of host fish and their tendencies to travel upstream and against the current (positive rheotaxis) in rivers and streams (USFWS, 2022). Host fish are necessary to facilitate dispersal and represent the only mechanism to do so in a free-flowing environment, although downstream movement of individuals may occur during high flow events if they become dislodged from the substrate. Large and small run of river impoundments and culverted and non-culverted (e.g., concrete pads) low water crossings act as barriers to fish passage, and therefore inhibit mussel dispersal and recolonization (USFWS, 2022).

Population Information and Trends

Population Trends:

Declining (overall declining, 1 stable population) (USFWS, 2022)

Number of Populations:

13 (USFWS, 2022)

Population Size:

Populations range in size from 3 to 7,045, depending on the population (USFWS, 2022)

Population Narrative:

. Given the current status encompasses 13 populations and 11 MUs throughout its range, the species currently retains redundancy for withstanding and surviving potential catastrophic events. However, it is important to note that a high percentage (45%) of MUs are currently in low condition. Overall, the species has decreased redundancy across its range compared to its historical range caused by the estimated 60% reduction in occupancy and the extirpation of 16 MUs (59%) (USFWS, 2022). Recruitment in some species of mussels is significantly related to components of spring and summer flow (Ries et al. 2016, p. 711). High velocity flows during spawning can decrease fertilization success (Ries et al. 2016, p. 712) and shear stress is the primary determinant of juvenile settling above a range of threshold flow (Daraio et al. 2010, p. 838; Hardison and Layzer 2001, p. 77). Hydraulic variables describing substrate stability at high flows are most limiting to mussel species richness and abundance (Allen and Vaughn 2010, p. 390). Mussel beds may be constrained by threshold limits at both flow extremes. Under low flow, mussels may require a minimum hydraulic variable (Reynolds number, Froude number) to transport nutrients, oxygen, and waste products. Under high flow, areas with relatively low boundary shear stress may provide hydraulic refuge (Steuer et al. 2008, p. 67). Zigler et al. (2008, p. 343) results suggest episodic events such as droughts and floods are important in structuring mussel distribution. Fanshell mussels undoubtedly evolved in the presence of extreme hydrological conditions to some degree, including severe droughts leading to dewatering, and heavy rains leading to damaging scour events and movement of mussels and substrate, although the frequency, duration, and intensity of these events may be different from today. Streamflow and overall discharge for rivers inhabited by Fanshell mussels will likely decline due to climate change and projected increases in temperatures and evaporation rates, resulting in more frequent and intense droughts (USFWS, 2022).

Threats and Stressors

Stressor: Water quality
Exposure:
Response:
Consequence:
Narrative: Freshwater mussels require water in sufficient quantity and quality on a consistent basis to complete their life cycles and those of their fish hosts. Along with natural perturbations that exert pressure on populations and influence survival, a variety of anthropogenic activities affect freshwater mussel habitat. These activities place increasing demands on natural resources, particularly water, which can have deleterious effects on both water quality and quantity. Hydrology, geomorphology, and landscape condition strongly influence water quality. Assessments of biological condition often integrate chemical and physical water quality information. Chemical and physical characteristics of air also substantially affect aquatic ecosystems (EPA 2012, p. 2-26). Chemical contaminants are ubiquitous in the environment and a major threat in the decline of mussel species (Cope et al. 2008, p. 451; Richter et al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007a, p. 2029). Chemicals enter rivers through point and nonpoint discharges including spills, industrial and municipal effluents, and residential and agricultural runoff. These sources contribute organic compounds, heavy metals, nutrients, pesticides, and a wide variety of newly emerging contaminants such as pharmaceuticals to the aquatic environment. There are Threats Habitat Factors Population Factors Water Quality Flow Landscape Connectivity Climate Change Changes to Water Quality Changes to Hydrology Landscape Changes Habitat Fragmentation Invasive Species Population Extent Population Size Change to Population Resiliency Reproduction/Recruitment Survival Host Fish Availability instances where chemical spills resulted in the loss of high mussel numbers (Brown et al. 2005, p. 1457; Schmerfeld 2006, pp. 12 – 13). The Fanshell mussels are especially threatened by chemical spills because these spills can occur anywhere that highways or railways, industries, pipelines or mines overlap with their distribution. For example, 93% and 100% of Western Fanshell and “Ouachita” Fanshell occupied streams have highway crossings. Fifty percent of “Ouachita” Fanshell occupied streams have crossings registered as hazardous material road routes. Four “Ouachita” Fanshell occupied streams have gas pipeline crossings, while two have oil and

hazardous liquid pipeline crossings within three MUs. Eleven Western Fanshell occupied streams have gas pipeline crossings, while eight have oil and hazardous liquid pipeline crossings within all MUs. These pipelines cross 92% of Western Fanshell occupied streams and 67% of “Ouachita” Fanshell occupied streams.

Stressor: Flow
Exposure:
Response:
Consequence:
Narrative: Watershed hydrology is driven by climatic processes, surface and subsurface characteristics (e.g., topography, vegetation, geology), and anthropogenic processes (e.g., water and land use; EPA 2012, p. 2-16). Natural flow regimes compose seasonally varying environmental flow components, including high flow, base flow, pulses, and floods. Each flow component serves critical ecological functions (e.g., creating habitat, spawning cues, etc.). Environmental flow characteristics include magnitude, frequency, duration, timing, and rate of change (EPA 2012, p. 2-17). Reductions in the diversity and abundance of mussels are principally attributed to habitat alteration caused by inundation of free-flowing rivers and streams (Neves et al. 1997, p. 60), including portions of the Fanshell mussels range (e.g., White, Ouachita, Caddo, and Neosho rivers). The construction of reservoirs and other impoundments permanently alters the hydrology, and hence, the ecology of rivers, with deleterious effects to water quality, water quantity, fish movement and mussel dispersal, nutrient cycling, sediment deposition, fate and transport of contaminants, and numerous other changes to the physicochemical and biological characteristics of affected areas (upstream and downstream).

Stressor: Landscape Changes
Exposure:
Response:
Consequence:
Narrative: Many rivers where the Fanshell mussels occur are threatened by land use activities and change (e.g., increased urbanization, alteration of riparian buffers, improperly designed and maintained unpaved roads). Life history traits of mussels render them poorly adapted to deal with landscape change (Strayer et al. 2004, p. 436). Effects of landscape disturbances, such as increased sedimentation, altered flow regimes, or elevated contaminant concentrations, may be slow and in some cases irreversible (Allan 2004, p. 258 – 260; Newton et al. 2008, p. 434). Urbanization of a watershed results in multiple stressors (e.g., increased pollutant loads from stormwater runoff, altered flow, decreased bank stability, and increased water temperature). Urbanization can also indirectly increase channel erosion and downstream sedimentation by increasing the frequency and volume of channel-altering storm flows (Hammer 1972, p. 1530; Leopold 1968, entire). Long Island urban streams had mean summer temperatures 5 – 8°C warmer and winter temperatures 1.5 – 3°C cooler than forested streams. Seasonal diurnal fluctuations were also greater in urban streams, and summertime storms resulted in increased temperature pulses 10 – 15°C warmer than forested streams, a result of runoff from heated impervious surface.

Stressor: Habitat Fragmentation
Exposure:
Response:
Consequence:

Narrative: Hydrologic and geomorphic processes directly relate to habitat extent. The number and distribution of habitat patches and their connectivity influence species population health. Water quality also affects habitat quality. Landscape condition affects water quality and hydrologic processes, which also shape riparian and terrestrial habitat. Thus, habitat condition serves as an integrating indicator of other watershed variables upon which biological condition is dependent (EPA 2012, p. 2-9). Historically, the Fanshell mussels likely occurred throughout the river basins described in Chapter 4. Given their reproductive ecology, they would colonize new areas of suitable habitat through movement of infested fish hosts. Today, major reservoirs and other anthropogenic effects (e.g., poor water and sediment quality from mining activities, channel maintenance for navigation, road crossings, etc.) isolate many of the remaining populations. These effects can be substantial causing permanent changes to fish movement, water quality, and hydrology. Largescale reductions in mussel diversity and abundance is largely due to habitat changes caused by impoundments (Neves et al. 1997, p. 63). The number of impoundments in “Ouachita” Fanshell MUs ranges from 3 – 51 and 4 – 73 in Western Fanshell MUs. The number of unpaved road crossings/km ranges from 0.11 – 0.56 in the Fanshell mussels MUs. Populations eliminated due to stochastic events cannot naturally recolonize, leading to reduced overall redundancy and representation.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Based on extensive evidence, the planet is warming and human activities, especially emissions of greenhouse gases, are the dominant cause. There is no convincing alternative explanation aside from human activities that accounts for the warming during the past century (Wuebbles et al. 2017, Executive Summary). The seasonal averages of 30 Coupled Model Intercomparison Project 5 (CMIP5) models from 1950 – 2100 using RCP4.5 and RCP8.51 indicate warming air temperatures in the Lower Mississippi River region (Figure 5.2), with a central tendency of < 2 inches change in precipitation (Figure 5.3; Alder and Hostetler 2013, p. 2). The range of potential values for air temperature and precipitation are shown in Figures 5.2 and 5.3 (Alder and Hostetler 2013, p. 2). We expect changes in stream temperatures to reflect changes in air temperature, at a rate of approximately 0.6 – 0.8°C increase in stream water temperature for every 1°C increase in air temperature (Morrill et al. 2005, pp. 1-2, 15). These water temperature changes will have implications for temperature dependent water quality parameters, such as dissolved oxygen and ammonia toxicity, spawning, and physiological effects to thermally sensitive species. In “Ouachita” Fanshell occupied streams from 1990 – 2018, the percent of water temperature samples exceeding 27°C ranged from 6.9 (Upper Ouachita MU) – 15.4% (Saline MU), with maximum water temperature ranging from 30.3 (Ouachita Headwaters MU) – 36.6°C (Saline MU). In Western Fanshell MUs from 1990 – 2018, the percent of water temperature samples exceeding 27°C ranged from 0 (Middle White MU) – 12.6% (Strawberry MU), with maximum water temperature ranging from 22.0 (Middle White MU) – 35.8°C (Spring MU).

Stressor: Invasive Species
Exposure:
Response:
Consequence:

Narrative: Invasive species, such as Asian Clam (Corbicula fluminea) and Zebra Mussel (Dreissena polymorpha) occur in portions of the Fanshell mussels range and can negatively affect mussel survival. Strayer (1999, pp. 75–80) reviewed in detail the mechanisms by which Zebra Mussels affect native mussels. Zebra Mussels also may affect Fanshell mussels through filtering and removing their sperm and possibly glochidia from the water column, thus reducing reproductive potential. They also may degrade habitat for native mussels by depositing large quantities of Zebra Mussel pseudofeces (undigested waste material passed out of the incurrent siphon) .

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2022. Species status assessment report for Western Fanshell (Cyprogenia aberti) and “Ouachita” Fanshell (Cyprogenia cf. aberti). August 2022 (Version 1.2). Columbia, Missouri.

USFWS. 2023. Endangered and Threatened Wildlife and Plants

Threatened Species Status With Section 4(d) Rule for Western Fanshell and ‘‘Ouachita’’ Fanshell and Designation of Critical Habitat. Final Rule. FR Vol. 88, No. 122. Pages 41724-41771.

SPECIES ACCOUNT: *Cyprogenia stegaria* (Fanshell)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 06/21/1990, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

Shell is inflated, thick, solid, somewhat rounded or subcircular. The ventral margin is long, broadly rounded; the posterior margin is bluntly angled or slightly truncated. The posterior ridge is well developed, producing a sharp angle behind the umbones, becoming rounded toward the ventral-posterior margin; sometimes the posterior ridge has a shallow sulcus between the ridge and the dorsal margin (on the flattened posterior slope). The posterior two-thirds of the shell is covered by numerous rounded pustules and irregular knobs; those on the center of the valve often appear in rows, being located on the distinct, elevated concentric ridges indicative of growth periods. Beaks are elevated and full; sculpture consists of a few indistinct, feeble ridges. Maximum length of individual is about 70 mm. The periostracum is a pale greenish yellow, covered with a pattern of darker green flecks or dots which may appear as rays; knobs and the ventral area are often lighter with less green. (Parmalee and Bogan 1998).

Historical Range

The fanshell was historically distributed in the Ohio, Wabash, Cumberland, And Tennessee Rivers and their larger tributaries in Pennsylvania, Ohio, West Virginia, Illinois, Indiana, Kentucky, Tennessee, Alabama, and Virginia (Johnson, 1980; KSNPC, 1980; Ahlstedt, 1986; Bates and Dennis, 1985; Cummings et al., 1987; Cummings et al., 1988; Starnes and Bogan, 1988; USFWS 1991b). It is believed that reproducing populations are now present in only three rivers, the Clinch River (Hancock County, TN and Scott County, VA), the Green River (Hart and Edmonson Counties, KY), and the Licking River (Kenton, Campbell, and Pendleton Counties, KY). In addition, based on collections of a few older individuals in the 1980s, small remnant (apparently nonreproducing) populations may still persist in the Muskingum River (Morgan and Washington Counties, OH), the Walhonding River (Coshocton County, OH), the Wabash River (White County, IL and Posey and Wabash Counties, IN), the East Fork White River (Martin County, IN), the Tippecanoe River (Tippecanoe County, IN), the Kanawha River (Fayette County, WV), Tygarts Creek (Greenup and Carter Counties, KY), the Barren River (Allen and Barren Counties, KY), the Cumberland River (Smith County, TN), and the Tennessee River (Rhea, Meigs, and Hardin County, TN) (USFWS, 1990; USFWS, 1991b). Survey information also indicates that the species has been found in the Salt River (tributaries to the Ohio River) and in the Allegheny River in Pennsylvania. Also, a small reproducing population may exist in the Tennessee River below Pickwick Landing Dam (Parmalee and Bogan, 1998).

Current Range

Although it has become very rare in recent years. In the Ohio drainage it has been recently found in: the deep channel of the Ohio River between Cincinnati and Pittsburgh (Johnson, 1980); the lower Muskingum and Walhonding Rivers, Ohio (Stansbery et al., 1982); the Salt and Licking Rivers, tributaries of the Ohio (Stansbery, pers. comm.); the Green River, Kentucky (USFWS, 1991) the Kanawha River, West Virginia (Stansbery, pers. comm.); the Allegheny River, Pennsylvania (Dennis, 1970); and the lower Clinch River in Scott County (Neves, 1991). It has recently been suggested that Cyprogenia aberti is not a monophyletic group and may comprise

2 and possibly 5 distinct taxa, one of which includes the federally endangered Cyprogenia stegaria (Serb, 2003; 2006) (see Element Management). Survey information also indicates that the species has been found in the Salt River (tributaries to the Ohio River) and in the Allegheny River in Pennsylvania. Also, a small reproducing population may exist in the Tennessee River below Pickwick Landing Dam (Parmalee and Bogan, 1998).

Critical Habitat Designated

Yes;

Life History

Reproduction Narrative

Adult: The life history details of the fanshell mussel are thought to be similar to other unionid mussel species (Parmalee and Bogan, 1998). Specific life history and propagation work has been completed for the fanshell since publication of the recovery plan (Jones and Neves, 2002). Cyprogenia stegaria is a long-term brooder and holds glochidia overwinter for a spring release (Ortmann, 1919). The glochidia are released in the form of a unique spiral worm-like conglutinate suggesting that this species relies on fish hosts that visually search for food (USFWS, 1991). Recent induced infestations of glochidia on nine of sixteen fish species tested indicate that the following species are suitable hosts: mottled sculpin (Cottus bairdi), banded sculpin (Cottus carolinae), greenside darter (Etheostoma blennioides), snubnose darter (Etheostoma simoterum), banded darter (Etheostoma zonale), tangerine darter (Percina aurantiaca), blotchside logperch (Percina burtoni), logperch (Percina caprodes), and Roanoke darter (Percina roanoka) (Jones and Neves, 2002).

Habitat Narrative

Adult: The fanshell inhabits medium to large rivers (Bates and Dennis, 1985). It has been reported primarily from relatively deep water in gravelly substrate with moderate current (Gordon and Layzer, 1989). It has also been found in river habitats with gravel substrates and a strong current, in both deep and shallow water (Ortmann, 1919; Parmalee, 1967). This species is endemic to the Ohio River system and found in flowing water and stable substrate which contains a relatively firm and clean gravel, sand, and silt mixture. Fanshell mussels are often associated with other riverine mussel species that also prefer this type of habitat. The fanshell was historically distributed in the Ohio, Wabash, Cumberland, And Tennessee Rivers and their larger tributaries in Pennsylvania, Ohio, West Virginia, Illinois, Indiana, Kentucky, Tennessee, Alabama, and Virginia (Johnson, 1980; KSNPC, 1980; Ahlstedt, 1986; Bates and Dennis, 1985; Cummings et al., 1987; Cummings et al., 1988; Starnes and Bogan, 1988; USFWS 1991b). It is believed that reproducing populations are now present in only three rivers, the Clinch River (Hancock County, TN and Scott County, VA), the Green River (Hart and Edmonson Counties, KY), and the Licking River (Kenton, Campbell, and Pendleton Counties, KY). In addition, based on collections of a few older individuals in the 1980s, small remnant (apparently nonreproducing) populations may still persist in the Muskingum River (Morgan and Washington Counties, OH), the Walhonding River (Coshocton County, OH), the Wabash River (White County, IL and Posey and Wabash Counties, IN), the East Fork White River (Martin County, IN), the Tippecanoe River (Tippecanoe County, IN), the Kanawha River (Fayette County, WV), Tygarts Creek (Greenup and Carter Counties, KY), the Barren River (Allen and Barren Counties, KY), the Cumberland River (Smith County, TN), and the Tennessee River (Rhea, Meigs, and Hardin County, TN) (USFWS, 1990; USFWS, 1991b). Survey information also indicates that the species has been found in the

Salt River (tributaries to the Ohio River) and in the Allegheny River in Pennsylvania. Also, a small reproducing population may exist in the Tennessee River below Pickwick Landing Dam (Parmalee and Bogan, 1998). Multiple occurrences of Cyprogenia stegaria have been documented in Kentucky in recent years. Most recently during surveys conducted by Lewis Environmental Consulting in 2012, 84 individuals of Cyprogenia stegaria were located in Pool 4 of the Green River and 12 individuals of Cyprogenia stegaria were located near Green River Mile 240.5 (Lewis, 2013). Fourteen individuals were also located during 2010 mussel surveys in Pool 4 of the Green River (Lewis Environmental Consulting, 2011). It is also known that the fanshell is abundant and reproducing in portions of the Licking River in Kentucky. The Green River in Kentucky supports what is considered to be a healthy, reproducing population of the species. The species' range within the Green River extends from Pool 4 upstream to Green River Lake, a distance of approximately 60 miles. Within the Green River, fanshells are considered to be recruiting, stable, and possibly increasing. This species is considered relatively common in portions of the Green River. Dr. Monte McGregor (KDFWR) has recently conducted quantitative and qualitative surveys at selected sites in the river. Fanshell mussel densities ranged from 0.05 to 0.09 mussels per square meter in the Green River. The population of this species in the Green River where it occurs is considered to be stable. Obvious recruitment, as evidenced by multiple size classes and juveniles, has been observed at several sites indicating conditions suitable for this species are present in the Green River.

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Trends:

Decreasing

Population Size:

~14

Population Narrative:

Multiple occurrences of Cyprogenia stegaria have been documented in Kentucky in recent years. Most recently during surveys conducted by Lewis Environmental Consulting in 2012, 84 individuals of Cyprogenia stegaria were located in Pool 4 of the Green River and 12 individuals of Cyprogenia stegaria were located near Green River Mile 240.5 (Lewis, 2013). Fourteen individuals were also located during 2010 mussel surveys in Pool 4 of the Green River (Lewis Environmental Consulting, 2011). It is also known that the fanshell is abundant and reproducing in portions of the Licking River in Kentucky. The Green River in Kentucky supports what is considered to be a healthy, reproducing population of the species. The species' range within the Green River extends from Pool 4 upstream to Green River Lake, a distance of approximately 60 miles. Within the Green River, fanshells are considered to be recruiting, stable, and possibly increasing. This species is considered relatively common in portions of the Green River. Dr. Monte McGregor (KDFWR) has recently conducted quantitative and qualitative surveys at selected sites in the river. Fanshell mussel densities ranged from 0.05 to 0.09 mussels per square meter in the Green River. The population of this species in the Green River where it occurs is considered to be stable. Obvious recruitment, as evidenced by multiple size classes and juveniles, has been observed at several sites indicating conditions suitable for this species are present in the Green River.

Threats and Stressors

Stressor: Water quality
Exposure:
Response:
Consequence:
Narrative: Ongoing threats to the fanshell include water quality degradation from point and non-point sources, particularly in tributaries that have limited capability to dilute and assimilate sewage, agricultural runoff, and other pollutants. In addition, the species is affected by hydrologic and water quality alterations resulting from the operation of impoundments. The presence of impoundments may have ameliorated the effects of downstream siltation on fanshells, but these structures also control river discharges and the many environmental parameters influenced by discharge, which may profoundly affect the ability of these populations to occupy or successfully reproduce in downstream habitats. A variety of instream activities (e.g., sand and gravel dredging, road construction, etc.) continue to threaten fanshell populations. Protecting these populations from the direct physical disturbance of such activities depends on accurately identifying the location of the populations. The indirect effects of altering the streambed configuration may cause changes in previously suitable habitat some distance from the disturbance. Coal, oil, and natural gas resources are present in some of the watersheds known to support fanshell mussels, especially the Green, Barren, and Clinch Rivers. Exploration and extraction of these resources can result in increased siltation, an altered hydrograph, and degraded water quality at a great distance downstream from the mine or well field. Land-based development including residential and agriculture activities near streams often results in loss of riparian habitat, increased stormwater runoff due to increased impervious surfaces, increased sedimentation due to loss of streamside vegetation, and subsequent degradation of streambanks. The fanshell mussel is now sparsely distributed within most of its highly restricted range. Except for populations in the Green, Licking, Rolling Fork, and Clinch Rivers, known populations represent remnants within the historical range of this species. It is unlikely fanshell populations are experiencing any genetic exchange between the different river populations.

Recovery

Recovery Actions:

- Many areas of historical occurrences cannot be restored because of river impoundment. Other former habitats can probably be recovered if water quality is sufficiently upgraded and mussels are reintroduced, provided the appropriate fish host is present. Concerted efforts to maintain water quality (monitor point source dischargers) and prevent siltation (land use in the watershed should be monitored) are required. Water quality should be carefully monitored, upstream impoundments should be prohibited, and wise land use practices in the watershed should be encouraged to minimize siltation resulting from construction and agriculture. This mussel requires flowing water in either riffle areas or deep water of rivers with suitable water quality, therefore, river modifications such as dredging and impoundment should be avoided. A monitoring program for the species would aid in the development of a management plan, as well as provide basic biological and ecological data. To effectively manage mussel species it is necessary to work out certain life history characteristics first. Because of their unusual life-cycle and dependence on fish for completion of that cycle, it is imperative that the host species for the fanshell be ascertained. The only reported host was the artificially induced laboratory infection on the goldfish, Cassius auratus (Chamberlain, 1934). Life history studies need to be done to identify age and size at sexual maturity, recruitment success, age class structure, and other important life history parameters. Research is needed to assess the success of watershed protection on mussel populations. Abundance and distribution of selected species needs to be monitored in order to ascertain how species abundances change over time. From that we can assess what land-use changes, conservation practices, and physical/chemical parameters are correlated with, and possibly responsible for, the biological changes.

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Conduct additional surveys of known populations to monitor their status and viability (USFWS, 2019). 2. Conduct propagation and culture of juveniles to a suitable stocking size (USFWS, 2019). 3. Continue to develop and utilize in-vitro transformation of larvae to provide juveniles for establishing new populations (USFWS, 2019). 4. Determine sensitivity of each life stage to selected contaminants that are likely to be found in streams in which the species currently resides and determine contaminant levels at potential augmentation and reintroduction sites, including assessment of interstitial water quality (USFWS, 2019). 5. An assessment of habitat should be completed to identify sites where fanshell mussel augmentation and re-establishment can be achieved (USFWS, 2019). 6. Identify and map threats and stressors within each river ecosystem that may affect the Fanshell mussel and its host fish at known sites of occurrence, and at potential augmentation and reintroduction sites (USFWS, 2019). 7. Age and growth analyses should be conducted to determine mean age-at-length and longevity of the species in the remaining reproducing populations (USFWS, 2019). 8. Development of a geospatial database, containing site specific information for each population that should include, but is not limited to: a. Occupied stream length. b. Assessment of population vulnerability. c. Survey results, including evidence of recruitments and survey dates. d. Habitat conditions including limiting factors. e. Opportunities for range expansion (USFWS, 2019) 9. Sites suitable for reintroduction efforts should be identified (USFWS, 2019).

References

USFWS 2016. Status of the Species and Critical Habitat: Cyprogenia stegaria (Fanshell). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS. 2019. Fanshell (Cyprogenia stegaria). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. Southeast Region. Kentucky Ecological Services Field Office. Frankfort, Kentucky. 22 pp.

SPECIES ACCOUNT: *Dromus dromas* (Dromedary pearlymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population; 06/14/1976, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

From USFWS (1983): D. dromas is a medium-sized species, rounded to subtriangular or subelliptical in outline with full, high beaks set forward. Valves are generally solid and inflated. Beak sculpture consists of a series of fine ridges running parallel with the growth lines. The outer surface of the shell near the median line has a strong concentric ridge or hump with a curved row of smaller knobs near the midline extending from the umbo area to the ventral margin. The outer covering of the shell is generally yellowish-green in color with broken green rays covering the shell. Inside coloration of the shell is generally white or pinkish in color.

Taxonomy

This species is placed in a monotypic genus closely related to the genus Elliptio (NatureServe 2015).

Historical Range

From USFWS (1983): D. dromas had a wide distribution in the upper Tennessee and Cumberland River drainage. Bogan and Parmalee (1983) documented the occurrence of D. dromas in the Little Tennessee River, based on prehistoric archaeological specimens. Relict specimens of D. dromas have also been reported from the Caney Fork (Cumberland River system) by John Schmidt (personal communication).

Current Range

From USFWS (2011): The dromedary pearlymussel is still known to reproduce in the Clinch River and Powell River (Nicholson 2006, pers. comm.). The population in the Cumberland River persists, but is no longer reproducing.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: From USFWS (1983): The glochidia of D. dromas are of the hookless type which are most frequently parasitic on the gill filaments of fish (Coker and Surber, 1911; Lefevre and curtis, 1910). From USFWS (2011): Fish hosts of the dromedary pearlymussel include the black sculpin (Cottus baileyi), greenside darter, fantail darter (E. flabellare), Tennessee snubnose darter, channel darter (Percina copelandi), gilt darter (P. evides), Roanoke darter (P. roanoka), tangerine darter (P. aurantiaca), and logperch (P. caprodes) (Jones et al. 2004).

Adult: This is a diurnal species (NatureServe 2015). This species feeds by siphoning water (USFWS 1983).

Reproduction Narrative

Adult: From USFWS (1983): Males produce sperm that are discharged into the surrounding water and dispersed by water currents. Any female D. dromas downstream obtains these sperm during the normal process of siphoning water during feeding a respiration (Stein, 1971). D. dromas is a bradytictic species (embryos develop in the female over winter and are released the following spring or summer) (Bogan and Parmalee, 1983). From NatureServe (2015): Females are gravid from October through May and contain 33 to 151 conglutinates/female. This species lives up to 25 years (Jones et al. 2004).

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe (2015)

Habitat Narrative

Adult: From USFWS (1983): Cumberlandian freshwater mussels are most often observed in clean, fast-flowing water in substrates that contain relatively firm rubble, gravel, and sand substrates swept free from siltation. D. dromas is categorized as a riffle species because it is typically found in shallow, fast-flowing water with stable, clean substrate. However, this species has been found alive in approximately 18 feet of water. From NatureServe (2015): Environmental specificity is narrow. This species only occurs in clean, silt-free, flowing water and is sensitive to changes in water quality (domestic pollution and coal washing) and physical disruption (USFWS, 1984).

Dispersal/Migration

Population Information and Trends

Population Trends:

Declining (USFWS 2020)

Population Size:

< 1000 (NatureServe 2015)

Population Narrative:

From USFWS (2011): Species status is uncertain. No information is available concerning the genetics or genetic trends of this species. NatureServe (2015): There are likely fewer than 1000 individuals. The Dromedary Pearlymussel is currently in decline, and its current area of known distribution is limited to the Clinch and Powell rivers near the VirginiaTennessee border. It has likely been extirpated from the Tennessee River (where it was believed extant at the time the recovery plan was written in 1983) and the Cumberland River (where it has not been found alive since 1994). Historically, the Dromedary Pearlymussel occupied approximately 1,810 miles of rivers and streams in Tennessee, Virginia, Alabama, Mississippi and Kentucky. Across its range, the species' area of known occupation has diminished to only 85 miles (a 95% reduction in range). The population in the Clinch River remain the most robust, but has suffered recent declines as a possible result of an on-going mussel die-off that was first documented in 2016. The Powell River population remains viable, but less robust than the one in the Clinch River.

Both remaining populations are small and highly localized and have declined since the last 5-year review in 2011. Because the Dromedary Pearlymussel remains restricted in distribution and continues to remain vulnerable to threats, we believe that no status change is required at this time as it still meets the Act's definition of endangered. (USFWS, 2020)

Threats and Stressors

Stressor: Mining (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2011): Over the past five years, biologists working in the Clinch River upstream from Norris Lake in Tennessee have reported the presence of increasing amounts of coal fines in the river. There have been no obvious adverse effects to the mussels in the Tennessee reach of the river to date, but malacologists report declines in overall mussel numbers in the Virginia reach. Impacts from increased mining activity in the upper Clinch River drainage could eventually have adverse effects on the best known populations of the dromedary pearlymussel

Stressor: Impoundments (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2011): Coldwater releases from Wolf Creek Dam (Cumberland River, Kentucky), Dale Hollow Dam (Obey River, Tennessee), and Center Hill Dam (Caney Fork River, Tennessee) have adversely affected the mussel populations in the middle reach of the Cumberland River. Although the dromedary pearlymussel persists in that reach, low water temperatures have precluded reproduction.

Recovery

Reclassification Criteria:
There are no downlisting criteria for this species (USFWS 2011).

Delisting Criteria:
1) A viable* population of dromedary pearlymussel exists in the Clinch River from the backwaters of Norris Reservoir upstream to approximately CRM 226 and in the Powell River from the backwaters of Norris Reservoir upstream to approximately PRM 130. These two populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population (USFWS 2011).

2) Through reestablishment and/or discoveries of new populations, viable populations exist in three additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate this mussel from the river system (USFWS 2011).

3) The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (USFWS 2011).

4) Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no foreseeable increase in coal-related siltation occurs in the Clinch River. If the Cumberland River, including its tributaries, is selected for transplants or new populations are discovered, then these improvements in coal-related problems and substrate quality also apply to these streams (USFWS 2011).

Recovery Actions:

- 1. Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat (USFWS 2011).
- 2. Survey rivers within the species' ranges to determine the availability and location of suitable transplant sites. This can include areas for population expansion within rivers where the species presently exists. (USFWS 2011).
- 3. Conduct life history studies not covered under section 1.2; i.e., fish hosts, age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics. (USFWS 2011).
- 4. Determine the number of individuals required to maintain a viable population (USFWS 2011).
- 5. Investigate the necessity for habitat improvement and if feasible and desirable identify techniques and sites for improvement to include implementation (USFWS 2011).
- 6. Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations (USFWS 2011).
- 7. Assess overall success of recovery program and recommend action (delist, continued protection, implement new measures, other studies, etc.) (USFWS 2011).
- Develop propagation technology for the cracking pearlymussel and birdwing pearlymussel. Continue propagation of the dromedary pearlymussel for augmentation of extant populations and reestablishment of new populations (USFWS 2011).
- Augment existing populations to ensure viability (USFWS 2011).
- Reestablish populations into suitable habitat in other streams within the species' historic ranges (USFWS 2011).
- Work with other Federal agencies, State agencies, individuals, and other partners to restore, maintain, and protect suitable habitat in the rivers containing extant and reestablished populations of these species (USFWS 2011).
- Continue to explore the feasibility of cryogenic preservation of gametes and/or larvae of the birdwing pearlymussel, dromedary pearlymussel, and cracking pearlymussel. Advances in cryopreservation technology since previous efforts with mussels may now make this technique of protecting genetic material feasible (USFWS 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Develop and implement a plan to quantify and monitor surviving populations. • Reintroduce into other streams within the historical range that have suitable habitat and water quality. For example, the following streams were recommended by the Cumberland Region Mollusk Restoration Committee (2010): Alabama (Tennessee River Drainage) -Tennessee River main steam below Wilson and Guntersville dams -Elk River -Limestone Creek Tennessee (Tennessee River Drainage) -Tennessee River main steam below Pickwick Dam -

Upper and Lower French Broad River -Lower Holston River -Lower Pigeon River -Hiwassee River -Nolichucky River -Elk River Tennessee-Kentucky (Cumberland River Drainage) -Big South Fork • Conduct studies to determine the cause of the mussel die-offs in the Clinch River. • Work with landowners of priority recovery or restoration parcels to identify, fund, and implement management actions to improve water quality. • Continue to educate the public about water quality and freshwater mussels. (USFWS, 2020)

References

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee

USFWS 1983. Dromedary Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia, 58 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 16, 2016).

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee. USFWS. 2020. Dromedary Pearlymussel Dromus dromas (Lea, 1834). 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 22 pp.

USFWS. 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee.

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee.

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office, Cookeville, Tennessee.

USFWS. 2020. Dromedary Pearlymussel Dromus dromas (Lea, 1834). 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 22 pp.

SPECIES ACCOUNT: *Elliptio chipolaensis* (Chipola slabshell)

Species Taxonomic and Listing Information

Listing Status: Threatened; March 16, 1998; Southeast Region (R4) (USFWS 2007)

Physical Description

From USFWS (2003): The Chipola slabshell is a medium-sized species reaching a length of about 3.3 in (8.4 cm). The shell is ovate to subelliptical, somewhat inflated, and with the posterior ridge starting out rounded but flattening to form a prominent biangulate margin. The periostracum is smooth and chestnut colored. Dark brown coloration may appear in the umbonal region and the remaining surface may exhibit alternating light and dark bands. The umbos are prominent, well above the hingeline. Internally, the umbone cavity is rather deep. The lateral teeth are long, slender, and slightly curved, with two in the left and one in the right valve. The pseudocardinal teeth are compressed and crenulate, with two in the left and one in the right valve. Nacre color is salmon, becoming more intense dorsally and somewhat iridescent posteriorly.

Taxonomy

From USFWS (2003): This taxon was originally described as Unio chipolaensis Walker, 1905, and was subsequently moved to the genus Elliptio chipolaensis by Frierson (1927).

Historical Range

Historically, this species was found in the lower Chattahoochee River in Alabama and Georgia, and the Chipola River in Florida (USFWS 2007).

Current Range

This species currently occurs in the Chipola River in Florida (USFWS 2007). From USFWS (2003): Currently, six subpopulations of Chipola slabshell remain in Marshall and Dry Creeks, and from the upper two-thirds of the Chipola River main stem. The largest remaining subpopulation appears to be on the Chipola River main stem in the vicinity of (but not in) Dead Lake, where the species remains relatively common (J.D. Williams, USGS, unpub. data).

Critical Habitat Designated

Yes; 11/15/2007.

Legal Description

On November 15, 2007, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the threatened Chipola slabshell (Elliptio chipolaensis) under the Endangered Species Act of 1973, as amended (72 FR 64286 - 64340).

Critical Habitat Designation

Critical habitat is designated for the Chipola slabshell (Elliptio chipolaensis)in Unit 2 in AL and FL.

Unit 2: Chipola River, Alabama and Florida. Unit 2 includes the main stem of the Chipola River (including the reach known as Dead Lake) and six of its tributaries, encompassing a total stream length of 190.0 km (118.1 mi) in Houston County, Alabama; and in Calhoun, Gulf, and Jackson counties, Florida. The main stem of the Chipola River as designated extends from its confluence with the Apalachicola River in Gulf County, Florida, upstream 144.9 km (90.0 mi) to the confluence of Marshall and Cowarts creeks in Jackson County, Florida. A short segment of the Chipola River that flows underground within the boundaries of Florida Caverns State Park in Jackson County, Florida, is not included in Unit 2. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The tributaries of the Chipola River included in Unit 2 are: Dry Creek, from the Chipola River upstream 7.6 km (4.7 mi) to Ditch Branch in Jackson County, Florida; Rocky Creek, from the Chipola River upstream 7.1 km (4.4 mi) to Little Rocky Creek in Jackson County, Florida; Waddells Mill Creek, from the Chipola River upstream 3.7 km (2.3 mi) to Russ Mill Creek in Jackson County, Florida; Baker Creek, from Waddells Mill Creek upstream 5.3 km (3.3 mi) to the confluence with Tanner Springs in Jackson County, Florida; Marshall Creek, from the Chipola River upstream 13.7 km (8.5 mi) to the Alabama-Florida State line in Jackson County, Florida (this creek is known as Big Creek in Alabama); Big Creek, from the AlabamaFlorida State line upstream 13.0 river km (8.1 river mi) to Limestone Creek, in Houston County, Alabama; and Cowarts Creek from the Chipola River in Jackson County, Florida, upstream 33.5 river km (20.8 river mi) to the Edgar Smith Road bridge, in Houston County, Alabama. This unit is designated for the fat threeridge (Brim Box and Williams 2000, p. 92–93; Miller 1998, p. 54), shinyrayed pocketbook (Williams unpub. data 2002; Brim Box and Williams 2000, p. 109–110; Smith unpub. data 2001; Blalock-Herod unpub. data 2000, 2003; Butler unpub. data 1993, 1994, 1999, 2000); Gulf moccasinshell (Butler unpub. data 1999, 2002; Brim Box and Williams 2000, p. 113–114; D.N. Shelton pers. comm. 1998); oval pigtoe (Butler unpub. data 1993, 1999, 2002; Brim Box and Williams 2000, p. 116–117; Williams unpub. data 2000); and Chipola slabshell (Butler unpub. data 1993, 2000; Brim Box and Williams 2000, p. 95–96). PCEs in Unit 2 are vulnerable to impacts from sedimentation, urbanization, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements of critical habitat are:

(i) A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);

(ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay;

(iii) Permanently flowing water;

(iv) Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387); and

(v) Fish hosts (such as largemouth bass, sailfin shiner, brown darter) that support the larval life stages of the seven mussels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on the effective date of the final rule and not containing one or more of the primary constituent elements.

Activities in or adjacent to each of the critical habitat units described in the rule may affect one or more of the PCEs that are found in the unit.

Management considerations to deal with sedimentation include protecting streams from sedimentation through application of agricultural and forestry best management practices, avoiding soiland vegetation-disturbing activity in the riparian zone, restoring unstable stream channels and other erosive areas, and other practices that prevent or reduce erosion.

Management considerations to deal with the threat of channel instability include avoiding soil- and vegetation-disturbing activity in the riparian zone, limiting impervious surface area, and other urban storm water runoff control methods.

Measures to deal with construction and operation of dams, water withdrawals, and water diversions threat include water conservation and operational strategies that manage water storage capacity and water demands in combination to minimize departures from the natural flow regime. Management considerations to deal with the threat of pollution include applying agricultural and forestry best management practices, preserving native vegetation in riparian zones, maintaining septic systems, and taking other measures to minimize pollutantladen runoff to streams.

Life History

Feeding Narrative

Larvae: From USFWS (2003): Glochidia must come into contact with specific species of fish whose gills and fins they temporarily parasitize, although two species have been shown to possibly utilize amphibian hosts (Howard 1915, 1951; Watters 1997a). Glochidia failing to come into contact with a suitable host will drift through the water column, surviving for only a few days at most (Sylvester et al. 1984, Neves and Widlak 1988, Jansen 1990, O'Brien and Williams 2002). Substances within the blood serum of the host fish are necessary for the transformation of a glochidium into a juvenile mussel (Isom and Hudson 1982). From USFWS (2007): Researchers from Columbus State University recently documented the successful transformation of glochidia on bluegill (Lepomis macrochirus) (L. Preister unpubl data 2007). Southeastern congeners of the Chipola slabshell have been documented to use centrarchids (sunfishes) as host fish (Keller and Ruessler 1997).

Juvenile: From USFWS (2003): Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juveniles up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Growth rates for freshwater mussels tend to be relatively rapid for the first few years (Chamberlain 1931, Scruggs 1960, Negus 1966), then slows appreciably (Bruenderman and Neves 1993, Hove and Neves 1994).

Adult: From USFWS (2003): Adult freshwater mussels are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Based on the findings of studies such as Baldwin and Newell (1991) and Neves et al. (1996), an omnivorous opportunistic diet would allow mussels to take advantage of whatever food type happens to be abundant. The relatively abrupt slowing in growth rate occurs at sexual maturity, probably due to energies being diverted from growth to gamete production.

Reproduction Narrative

Adult: From USFWS (2003): No age specific information is available for this species. However, some Virginia subpopulations of Cumberland moccasinshell, Medionidus conradicus (Lea, 1834) and Tennessee clubshell, Pleurobema oviforme (Conrad, 1834) (species related to those considered in this recovery plan) were found to have individuals up to 24 and 56 years old, respectively (Moyer and Neves 1984). The age of sexual maturity for mussels is variable, usually requiring from three (Zale and Neves 1982) to nine (Smith 1979) years. Males expel clouds of sperm into the water column, although some species expel spermatozeugmata (sperm balls), which are comprised of thousands of sperm (Barnhart and Roberts 1997). Females draw in sperm with the incurrent water flow. It is suspected that this species expels conglutinates and is a tachytictic summer releaser.

Environmental Specificity

Adult: Narrow (inferred from USFWS 2003)

Tolerance Ranges/Thresholds

Adult: Low (USFWS 2003)

Habitat Narrative

Adult: From USFWS (2003): Stream geomorphic and substrate stability is especially crucial for the maintenance of diverse, viable mussel beds (Vannote and Minshall 1982, Hartfield 1993, Di Maio and Corkum 1995). Where substrates are unstable, conditions are generally poor for mussel habitation. The Chipola slabshell inhabits silty sand substrates of large creeks and the main channel of the Chipola River in slow to moderate current (Williams and Butler 1994). Specimens are generally found in sloping bank habitats. Nearly 70 percent of the specimens found during the status survey were associated with a sandy substrate (Brim Box and Williams 2000). Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987).

Dispersal/Migration

Motility/Mobility

Juvenile: Low (USFWS 2003)

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Non-migratory (USFWS 2003)

Dispersal

Juvenile: Moderate (inferred from USFWS 2003)

Dependency on Other Individuals or Species for Dispersal

Juvenile: Fish host (USFWS 2003)

Dispersal/Migration Narrative

Juvenile: From USFWS (2003): After dropping from fish hosts, newly metamorphosed juveniles passively drift with currents and ultimately settle in depositional areas with other suspended solids (Neves and Widlak 1987, Yeager et al. 1994). Parasitism serves as a means of dispersal for this relatively sedentary group (Neves 1993).

Population Information and Trends

Population Trends:

Unknown (USFWS 2007)

Number of Populations:

16 (USFWS 2007)

Population Narrative:

From USFWS (2007): The Service is presently funding a mussel survey to determine the status and distribution of the Chipola slabshell in the Chipola Basin. Those surveying in conjunction with this study have collected over 300 individuals from 10 new subpopulations and six previously known subpopulations.

Threats and Stressors

Stressor: Habitat modification and degradation (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2007): The declining range and abundance of this species is mostly due to changes in riverine habitat resulting from dams, dredging, mining, channelization, pollution, sedimentation, and water withdrawals. Sedimentation and water pollution continue to be an almost ubiquitous threat in the range of this species. Sand and gravel mining, dredging, and channelization also affect channel stability and improper road crossing structures may prevent passage of fish hosts.

Stressor: Insufficient host fish densities (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: Riverine fish populations in the Southeast generally have been adversely affect by a variety of the same habitat alterations that have contributed to the decline of the region's mussel fauna (Etnier 1997; Neves et al. 1997; Warren et al. 1997).

Stressor: Non-indigenous species (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: From USFWS 2007: Flathead catfish and blue catfish have been introduced in the ACF. These fishes are known to consume mussels and fishes and negatively impact fish populations

that may be hosts for endangered unionids. Monitoring data from FWS indiate that populations of redbreast sunfish, snail and spotted bullhead catfish, and other species have declined since the late 1980s, which may be the result of predation by the flathead catfish (T. Hoehn, pers comm.).

Recovery

Delisting Criteria:
1. The 1 existing population of Chipola slabshell exhibits a stable or increasing trend, natural recruitment, and multiple age classes (USFWS, 2019).

2. The population occupies each of the 3 delineated units to protect against extinction from catostrophic events and maintain adaptive potential (USFWS, 2019).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (USFWS, 2019).

Recovery Actions:
- 1. Secure extant subpopulations and currently occupied habitats and ensure subpopulation viability (USFWS 2003).
- 2. Search for additional subpopulations of the species and suitable habitat (USFWS 2003).
- 3. Determine through research and propagation technology the feasibility of augmenting extant subpopulations and reintroducing or reestablishing the species into historical habitat (USFWS 2003).
- 4. Develop and implement a program to evaluate efforts and monitor subpopulation levels and habitat conditions of existing subpopulations, as well as newly discovered, reintroduced, or expanding subpopulations (USFWS 2003).
- 5. Develop and utilize a public outreach and environmental education program (USFWS 2003).
- 6. Assess the overall success of the recovery program and recommend actions (USFWS 2003).
- 1. Mussel surveys upstream of Florida Caverns State Park to headwaters of the Chipola River are needed to determine the overall size and distribution of the overall size and distribution of the Chipola slabshell population (USFWS, 2019).
- 2. Genetic information from individuals of Chipola slabshell from the 3 units are needed to determine the heterozygosity of the population, allowing for additional assurance of viability over time (USFWS, 2019).
- 1. The subpopulation recovery criteria defining a subpopulation as a site is vague and less meaningful than actual density or population estimates. As USFWS acquires more information about population characteristic, USFWS should revise recovery criteria. The USFWS recommends using quantitative methods to monitor changes in population size with each sub-basin (USFWS 2007).
- 2. Define "viable subpopulation" through implementation of Recovery Tasks 1.3.6, 1.3.7, and 1.3.8 (USFWS 2007).
- 3. Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders (USFWS 2007).
- 4. Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies (USFWS 2007).

- 5. Work with the EPA and States to modify numerical water quality criteria for ammonia and copper (USFWS 2007).
- 6. Develop and implement a program to monitor subpopulation levels and habitat conditions of existing subpopulations (USFWS 2007).
- 7. Continue re-evaluating threats to these mussels (USFWS 2007).

References

USFWS 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida.

U.S. Fish and Wildlife Service. 2007. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Final rule. 72 FR 64286 - 64340 (November 15, 2007).

U.S. Fish and Wildlife Service. 2003. Recovery Plan for Endangered Fat Threeridge (Amblema neislerii), Shinyrayed Pocketbook (Lampsilis subangulata), Gulf Moccasinshell (Medionidus penicillatus), Ochlockonee Moccasinshell (Medionidus simpsonianus), and Oval Pigtoe (Pleurobema pyriforme)

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp.

USFWS 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

USFWS. 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida.

USFWS. 2007. Fat Three ridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus penicillatus) Ochlocknee Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

USFWS. 2019. Chipola Slabshell Recovery Plan Amendment to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for Endangered Fat Threeridge (Amblema neislerii), Shinyrayed Pocketbook (Lampsilis subangulata), Gulf Moccasinshell (Medionidus penicillatus), Ochlockonee Moccasinshell

(Medionidus simpsonianus), and Oval Pigtoe (Pleurobema pyriforme)

USFWS 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office, Panama City, Florida.

SPECIES ACCOUNT: *Elliptio lanceolata* (Yellow lance)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The Yellow Lance is a bright yellow, elongated mussel with a shell over twice as long as tall, usually no more than 3.4 inches in length (USFWS, 2018).

Historical Range

The yellow lance’s documented historical range spans eight Atlantic Slope river basins, including the Patuxent, Potomac, Rappahannock, York, James, Chowan, Tar-Pamlico, and Neuse drainages; however, the species is presumed extirpated in the Potomac River basin (Service 2019; Figure 1). An analysis of the species’ status conducted in 2016 estimated that six extant populations had low resiliency, meaning they are likely not self-sustaining populations, lack evidence of recruitment, and have very limited or fragmented distribution (i.e., Patuxent, Rappahannock, York, James, Chowan, and Neuse populations; Table 1). Only the Tar River population had an overall moderate resiliency with self-sustaining subpopulations, exhibiting evidence of multiple age classes, and with recruitment rates exceeding mortality rates (USFWS, 2023).

Current Range

DC, MD, NC, VA; The Yellow Lance has a historical range from the Patuxent River Basin in Maryland to the Neuse River Basin in North Carolina and has been documented from multiple physiographic provinces, from the foothills of the Appalachian Mountains through the Piedmont and into the Coastal Plain, from small streams (like Johns Creek) to large rivers (like the Tar River).

Critical Habitat Designated

Yes;

Life History

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2018)

Habitat Narrative

Adult: The Yellow Lance is a sand-loving species often found buried deep in clean, course to medium sand and sometimes migrating with shifting sands, although it has been found in gravel substrates. This species is dependent on clean, moderate flowing water with high dissolved oxygen content in riverine or larger creek environments (USFWS, 2018)

Dispersal/Migration

Population Information and Trends

Population Trends:

Declining (USFWS, 2023)

Resiliency:
Low

Representation:
Representation characterizes a species' adaptive potential by assessing geographic, genetic, ecological, and niche variability. The Yellow Lance has exhibited historical variability in the physiographic regions it inhabited, as well as the size and range of the river systems it inhabited. The species has been documented from small streams to large rivers in multiple physiographic provinces, from the foothills of the Appalachian Mountains through the Piedmont and into the Coastal Plain. Much of the representation of the Yellow Lance has been lost; physiographic variability has been lost with 70% loss in occupancy in the Coastal Plain and 56% loss in the Piedmont, and although the species persists in the majority of historically known river basins, those occurrences are represented by very few individuals in few locations (USFWS, 2019).

Redundancy:
Redundancy describes the ability of the species to withstand catastrophic disturbance events; for the Yellow Lance, we considered whether the distribution of resilient MUs within populations was sufficient for minimizing the potential loss of the species from such an event. The Yellow Lance historically ranged from the Patuxent River Basin in Maryland to the Neuse River Basin in North Carolina, but both the number and distribution of populations occupying that historical range has declined over the past 60 years (USFWS, 2019).

Number of Populations:
4 (USFWS, 2023)

Population Narrative:
The yellow lance is a freshwater mussel species native to Atlantic Slope rivers in Maryland, Virginia, and North Carolina. Populations are currently known from seven of eight historically occupied river basins; six have low resiliency and one has moderate resiliency. Although some augmentation efforts have improved abundance in portions of the Tar River population and recent monitoring efforts showed some limited evidence of reproduction in the Patuxent, Rappahannock, and Tar populations, surveys indicate that detection and abundance of the yellow lance remain in decline (USFWS, 2023).

Threats and Stressors

Stressor: Decline in Water Quality
Exposure:
Response:
Consequence:
Narrative:

Stressor: Loss of stream flow.
Exposure:
Response:
Consequence:

Narrative:

Stressor: Riparian and instream fragmentation
Exposure:
Response:
Consequence:
Narrative:

Stressor: Deterioration of instream habitats
Exposure:
Response:
Consequence:
Narrative:

Stressor: Agricultural Practices (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Agricultural best management practices (BMPs) are changes in agricultural land management that can be focused on achieving multiple positive environmental outcomes. A wide variety of agricultural BMPs exist, including practices such as cover crops, conservation tillage, irrigation efficiency, contour farming, and agroforestry; these practices aim to reduce agrichemical pollution and erosion, manage nutrient and sediment runoff, and protect streams. The US Department of Agriculture's Natural Resource Conservation Service has prepared national technical guidance on conservation practices and activities that can be adapted at the local level, and incentives are available for local farmers to participate in programs to promote agricultural conservation practices (USDA 2018, entire). (USFWS, 2019)

Stressor: Invasive Species (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: The South Atlantic seaboard has many native species that are declining and nonnative nuisance species are one of the major causes. It is estimated that 42% of Federally Threatened or Endangered species are significantly impacted by nonnative nuisance species across the nation and nuisance species are significantly impeding recovery efforts for them in some way (NCANSMPC 2015, pp.8-9). There are many areas across the states of Maryland, Virginia, and North Carolina where aquatic invasive species have invaded aquatic communities; are competing with native species for food, light, or breeding and nesting areas; and are impacting biodiversity. (USFWS, 2019)

Recovery

Reclassification Criteria:
Recovery Priority Number: 11C (USFWS, 2023)

Recovery Actions:

- 1. Establish long-term monitoring of Yellow Lance populations with associated habitat characteristics and conditions (USFWS, 2018)
- 2. Continue to develop and implement technology for maintaining and propagating the Yellow Lance in captivity, including collection of broodstock from each MU (USFWS, 2018).
- 3. Develop an augmentation and reintroduction plan for the species and assess the feasibility of reintroducing the species into restored habitats within the historical range (USFWS, 2018).
- 4. Conduct research on the genetics of the Yellow Lance and apply the results towards management and recovery actions for the species (USFWS, 2018).
- 5. Work with local entities, including land trusts, local governments, and watershed groups to restore and or protect stream reaches where the species currently exists and where we plan to reintroduce the species (USFWS, 2018).
- 6. Develop and implement programs to educate the public and private industry on the need and benefits of ecosystem management, and to involve them in stewardship and Yellow Lance recovery efforts (USFWS, 2018).
- 7. Evaluate and identify existing stressors and sources of threats throughout the species range and evaluate or refine BMPs and utilize existing agency programs to minimize, mitigate and/or remove threats, incentivize conservation, and prioritize areas in the Rappahannock, James, Nottoway, and Tar drainages for protection, enhancement, and restoration, including assessing water usage and land use changes (USFWS, 2018).
- 8. Monitor exotic invasive specie and investigate possible control measures (USFWS, 2018).
- 9. Utilize section 7(a)(1) and 7(a)(2) of the Endangered Species Act as mechanisms for conservation of the Yellow Lance (USFWS, 2018).

Conservation Measures and Best Management Practices:

- Permits to fill wetlands and fill, culvert, bridge or re-align streams or water features are issued by the U.S. Army Corps of Engineers under Nationwide, Regional General Permits or Individual Permits. ● Nationwide Permits are for “minor” impacts to streams and wetlands, and do not require an intense review process. These impacts usually include stream impacts under 150 feet, and wetland fill projects up to 0.50 acres. Mitigation is usually provided for the same type of wetland or stream impacted, and is usually at a 2:1 ratio to offset losses and make the “no net loss” closer to reality. ● Regional General Permits are for various specific types of impacts that are common to a particular region; these permits will vary based on location in a certain region/state. ● Individual permits are for the larger, higher impact and more complex projects. These require a complex permit process with multi-agency input and involvement. Impacts in these types of permits are reviewed individually and the compensatory mitigation chosen may vary depending on project and types of impacts. (USFWS, 2019a)
- RECOMMENDED FUTURE ACTIVITIES This species does not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities as focal areas over the next five years; these also are documented in the draft recovery plan (Service 2022b). Recovery Activities • Continue and expand captive propagation efforts to support augmentation and reintroduction of populations within the species’ current and historical range, as appropriate, and develop propagation/augmentation plans to strategically focus efforts. • Develop a rangewide genetics program, prioritizing topics that inform monitoring, management, and population restoration efforts, and resolve the taxonomy of the species. • Develop and implement a long-term population and habitat monitoring program, and consistently monitor the status of known populations and augmented/reintroduced populations. • Maintain, enhance, and restore habitat by

using voluntary conservation practices, removal of barriers, and land acquisition/conservation easements in watersheds that support yellow lance to protect extant populations and reduce threats. Early focus should be on riparian areas adjacent to locations with occurrence records or designated critical habitat. • Coordinate with local, state, and federal entities to promote yellow lance recovery, including using existing agency programs to minimize, mitigate, or remove threats; developing methods to incentivize conservation; and increasing public awareness of the need to protect the species and is habitats. • Identify and evaluate the magnitude of site-specific stressors affecting yellow lance populations (e.g., sedimentation, invasive species, industrial effluents, nonpoint source pollution, climate/land use factors), and manage for their abatement. • Implement protective water quality standards, classifications, and protections in waters within the species' range to address ongoing threats from a variety of land use practices. • Use and refine the recently-developed rangewide species distribution model to inform species restoration efforts, recovery actions, and conservation planning assistance work (USFWS, 2023).

References

USFWS. 2018. Recovery Outline for the Yellow Lance (Elliptio lanceolata).   USFWS. 2023. Yellow Lance (Elliptio lanceolata) 5-Year Review: Evaluation and Summary. Southeast Region. Raleigh Ecological Services Field Office. Raleigh, North Carolina. 13 pp.

USFWS. 2018. Recovery Outline for the Yellow Lance (Elliptio lanceolata).

USFWS. 2019. Species status assessment report for the Yellow Lance (Elliptio lanceolata). Version 1.4. February, 2019. Atlanta, GA. USFWS. 2023. Yellow Lance (Elliptio lanceolata) 5-Year Review: Evaluation and Summary. Southeast Region. Raleigh Ecological Services Field Office. Raleigh, North Carolina. 13 pp.

U.S. Fish and Wildlife Service. 2019. Species status assessment report for the Yellow Lance (Elliptio lanceolata). Version 1.4. February, 2019. Atlanta, GA.

USFWS. 2019. Species status assessment report for the Yellow Lance (Elliptio lanceolata). Version 1.5. May, 2019. Atlanta, GA.

USFWS. 2023. Yellow Lance (Elliptio lanceolata) 5-Year Review: Evaluation and Summary. Southeast Region. Raleigh Ecological Services Field Office. Raleigh, North Carolina. 13 pp.

USFWS. 2019a. Species status assessment report for the Yellow Lance (Elliptio lanceolata). Version 1.5. May, 2019. Atlanta, GA.

SPECIES ACCOUNT: *Elliptio spinosa* (Altamaha Spinymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered; November 10, 2011; Southeast Region (R4) (USFWS 2011)

Physical Description

From USFWS (2011): This species reaches a shell length of approximately 11.0 centimeters (cm) (4.3 inches (in)). The shell is subrhomboidal or subtriangular in outline and moderately inflated. As the name implies, the shells of these animals are adorned with one to five prominent spines. These spines may be straight or crooked, reach lengths from 1.0 to 2.5 cm (0.39 to 0.98 in), and are arranged in a single row that is somewhat parallel to the posterior ridge. In young specimens, the outside layer or covering of the shell (periostracum) is greenish-yellow with faint greenish rays, but as the animals get older, they typically become a deep brown, although some raying may still be evident in older individuals. The interior layer of the shell (nacre) is pink or purplish (Johnson 1970, p. 303).

Taxonomy

From USFWS (2011): The Altamaha spinymussel is a freshwater mussel in the family Unionidae, endemic to (found only in) the Altamaha River drainage of southeastern Georgia.

Historical Range

The historical range of the Altamaha spinymussel was restricted to the main stem of the Altamaha River and the lower portions of its three larger tributaries- the Ohoopee, Ocmulgee, and Oconee Rivers (USFWS, 2023)

Current Range

From USFWS (2011): This spinymussel is known only from Georgia in Glynn, Ben Hill, McIntosh, Telfair, Tattnall, Long, Montgomery, Toombs, Wheeler, Appling, Jeff Davis, Coffee, and Wayne Counties. The Altamaha spinymussel is considered extirpated from two rivers in its historical range, the Ohoopee (15 km (9 mi)) and Oconee Rivers (45 km (28 mi)), as well as the lower 73 km (45 mi) of the Altamaha River.

Critical Habitat Designated

Yes; 10/11/2011.

Legal Description

On October 11, 2011, the U.S. Fish and Wildlife Service designated critical habitat for the Altamaha spinymussel (Elliptio spinosa), a freshwater mussel endemic to the Altamaha River drainage of southeastern Georgia, under the Endangered Species Act of 1973, as amended (76 FR 62928 - 62960). The critical habitat includes approximately 237.4 kilometers (km) (147.5 miles (mi)) of mainstem river channel in Appling, Ben Hill, Coffee, Jeff Davis, Long, Montgomery, Tattnall, Telfair, Toombs, Wayne, and Wheeler Counties, Georgia (76 FR 62928 - 62960).

Critical Habitat Designation

Four units, totaling approximately 237.4 km (147.5 mi), are designated as critical habitat for the Altamaha spinymussel. The critical habitat units include the river channels below the ordinary high water mark. As defined in 33 CFR 329.11, the ordinary high water mark on nontidal rivers is the line on the shore established by the fluctuations of water and indicated by physical characteristics, such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas.

Unit 1: Ocmulgee River, Ben Hill, Telfair, Coffee, and Jeff Davis Counties. Unit 1 includes 110 km (68.3 mi) of the lower Ocmulgee River from the confluence of House Creek with the Ocmulgee River at Red Bluff Landing in Ben Hill and Telfair Counties, downstream to the Altamaha River (at the confluence of the Oconee and Ocmulgee Rivers, Jeff Davis and Telfair Counties). Live Altamaha spinymussels have been collected from 11 sites within Unit 1, the uppermost near Red Bluff (Thomas and Scott 1965, p. 67). Surveys conducted since 1997 on the Ocmulgee River have yielded 19 Altamaha spinymussels from 7 sites (Cammack et al. 2001, p. 11; O'Brien 2002, p. 2; Dinkins 2004, pp. 1–1, 2–1). The entire reach of the Ocmulgee River that composes Unit 1 is occupied. This unit contains all of the PCEs. The Altamaha spinymussel and its habitat may require special management considerations or protection to address changes in the existing flow regime due to activities such as impoundment, water diversion, or water withdrawal; alteration of water chemistry or water quality; and changes in streambed material composition and quality from activities that would release sediments or nutrients into the water, such as deadhead logging (instream log salvage), construction projects, livestock grazing, timber harvesting, and off-road vehicle use.

Unit 2: Upper Altamaha River, Wheeler, Toombs, Montgomery, Jeff Davis, Appling, and Tatnall Counties. Unit 2 includes a total of 62.1 km (38.6 mi) of the Altamaha River from the confluence of the Ocmulgee and Oconee Rivers (Wheeler and Jeff Davis Counties) downstream to the confluence of the Altamaha and Ohoopee Rivers (Appling and Tattnall Counties). Unit 2A includes 31.4 km (19.5 mi) of the Altamaha River from the confluence of the Ocmulgee and Oconee Rivers to Route 1. Unit 2B includes 30.7 km (19.1 mi) of the Altamaha River from the upstream boundary of Moody Forest to the confluence of the Altamaha and Ohoopee Rivers. However, we are not including in this critical habitat designation a stretch of the Altamaha River from U.S. Route 1 downstream to the State-owned property of Moody Forest (2.7 km (1.7 mi)), which includes Plant Hatch. This area does not contain the PCEs necessary for the Altamaha spinymussel due to: (1) Dredging for intake pipes at Plant Hatch, which destabilizes the river channel and banks, sandbar, slough, and mid-channel-island habitats and disrupts the movement of coarse-to-fine sand substrates with low to moderate amounts of fine sediment; and (2) Thermal discharges from Plant Hatch that reduce water quality. In the upper Altamaha River, historic surveys collected Altamaha spinymussels from 15 sites, while recent surveys have collected live Altamaha spinymussels from only 2 sites; dead shells have been collected from an additional 14 sites (Sickel 1980; Keferl 1995, p. 3; Cammack et al. 2001, p. 11, O'Brien 2002, p. 2; Wisniewski 2009, pers. comm.). The entire reach of the Altamaha River that composes Unit 2 is occupied. This unit contains all of the PCEs. The Altamaha spinymussel and its habitat may require special management considerations or protection to address changes in the existing flow regime due to activities such as impoundment, water diversion, or water withdrawal; alteration of water chemistry or water quality; and changes in streambed material composition and quality from activities that would release sediments or nutrients into the water, such as deadhead logging (instream log salvage), construction projects, livestock grazing, timber harvesting, and off-road vehicle use.

Unit 3: Middle Altamaha River, Tattnall, Appling, Wayne, and Long Counties. Unit 3 includes approximately 50.9 km (31.6 mi) of the Altamaha River from the confluence with the Ohoopee (Tattnall and Appling Counties) downstream to U.S. Route 301 (Wayne and Long Counties). Historic and recent surveys of the middle Altamaha River have yielded live Altamaha spinymussels from 26 sites. Shell material was found at an additional 13 sites (Keferl 1981, p. 14; Keferl 1995, p. 3; Cammack et al. 2001, p. 11; O'Brien 2002, p. 2; Wisniewski 2009, pers. comm.). The entire reach of the Altamaha River that composes Unit 3 is occupied. This unit contains all of the PCEs. The Altamaha spinymussel and its habitat may require special management considerations or protection to address changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal; alteration of water chemistry or water quality; and changes in streambed material composition and quality from activities that would release sediments or nutrients into the water, such as deadhead logging (instream log salvage), construction projects, livestock grazing, timber harvesting, and off-road vehicle use.

Unit 4: Lower Ohoopee River, Tattnall County. Unit 4 includes the lower 14.4 km (9 mi) of the Ohoopee River, from 2.2 km (1.3 mi) upstream of Tattnall County Road 191, downstream to the confluence of the Ohoopee and the Altamaha River in Tattnall County, Georgia. The Altamaha spinymussel historically occupied this stretch of the Ohoopee River but has not been found here since the mid-1990s (Stringfellow and Gagnon 2001, pp. 1–2) and is considered extirpated. Historic collections were made from seven sites (Keferl 1981, p. 14). Keferl (1981, p. 15) considered the Ohoopee to contain excellent habitat that would serve as a refuge for declining mussel populations. This stretch of the Ohoopee River contains PCEs 1, 2, and 4 for the Altamaha spinymussel, and continues to support four species commonly associated with the presence of the Altamaha spinymussel: Elliptio dariensis (75 percent of sites with E. spinosa), E. hopetonensis (93 percent), E. shepardiana (80 percent), and Lampsilis dolabraeformis (90 percent). Lampsilis splendida was found at 72 percent of sites (Wisniewski 2009, pers. comm.). The Ohoopee does not meet state water quality standards for mercury, however, EPA will begin revising needed load reductions in 2011 (EPA 2002b, p. 2). Critical habitat units 1, 2, and 3 are contiguous, making them very vulnerable to a catastrophic event that could eliminate all known occupied habitat for the Altamaha spinymussel. Therefore, we believe that the stream segment within this unit is essential to the conservation of the species because reestablishing the Altamaha spinymussel on a separate tributary such as the Ohoopee River would significantly reduce the impact of stochastic threats to the species' survival.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Appling, Ben Hill, Coffee, Jeff Davis, Long, Montgomery, Tattnall, Telfair, Toombs, Wayne, and Wheeler Counties, Georgia. The primary constituent elements (PCEs) of critical habitat for the Altamaha spinymussel are the habitat components that provide:

(i) Geomorphically stable river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with stable sandbar, slough, and mid-channelisland habitats of coarse-to-fine sand substrates with low to moderate amounts of fine sediment and attached filamentous algae.

(ii) A hydrologic flow regime (the magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for sand bar maintenance, food availability, and spawning habitat for native fishes.

(iii) Water quality necessary for normal behavior, growth, and viability of all life stages, including specifically temperature (less than 32.6 °C (90.68 °) with less than 2 °C (3.6 °F) daily fluctuation), pH (6.1 to 7.7), oxygen content (daily average DO concentration of 5.0 mg/l and a minimum of 4.0 mg/l), an ammonia level not exceeding 1.5 mg N/L, 0.22 mg N/L (normalized to pH 8 and 25 °C (77 °F)), and other chemical characteristics.

(iv) The presence of fish hosts (currently unknown) necessary for recruitment of the Altamaha spinymussel. The continued occurrence of diverse native fish assemblages currently occurring in the basin will serve as an indication of host fish presence until appropriate host fishes can be identified for the Altamaha spinymussel.

Special Management Considerations or Protections

Critical habitat does not include manmade structures existing on the effective date of this rule and not containing one or more of the PCEs, such as buildings, bridges, aqueducts, airports, and roads, and the land on which such structures are located.

Approximately 148 km (92 mi) have no protection. Various activities in or adjacent to each of the critical habitat units described in this final rule may affect one or more of the PCEs and may require special management considerations or protection. Features in all the final critical habitat units may require special management due to threats posed by land-use runoff and point- and nonpoint-source water pollution.

Life History

Feeding Narrative

Larvae: From USFWS (2011): To ensure survival, glochidia must come into contact with a specific host fish or fishes to develop into juvenile mussels. The host fish of the Altamaha spinymussel is currently unknown.

Juvenile: From USFWS (2011): For the first several months, juvenile mussels employ pedal (foot) feeding, extracting bacteria, algae, and detritus from the sediment (Yeager 1994, pp. 217–221; Cope et al. 2008, p. 457).

Adult: From USFWS (2011): Adult freshwater mussels are filter feeders, siphoning phytoplankton, diatoms, and other microorganisms from the water column.

Reproduction Narrative

Adult: From USFWS (2011): Although the life history of the Altamaha spinymussel has not been studied, the life histories of other mussels in the Elliptio genus have been. Internal fertilization results in the female brooding the larvae (glochidia), which when mature are released. Other mussels in the genus Elliptio are broadcast releasers, which may release conglutinates that resemble insect larvae. This reproductive strategy depends on clear water during the time of the year when mussels release their glochidia (Hartfield and Hartfield 1996, p. 375). The Altamaha spinymussel is thought to reproduce in late spring and release glochidia by May or June (Johnson 2004, p. 2; Bringolf 2011, pers. comm.). From NatureServe (2015): The reproductive success appears to be drastically reduced because very few juveniles or even small individuals are found.

Geographic or Habitat Restraints or Barriers

Adult: Land or anthropogenic barriers, lack of lotic connections, water depth > 10 m (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Clumped (USFWS 2011)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Habitat Narrative

Adult: From USFWS (2011): This spinymussel is considered a ‘‘big river’’ species; is associated with stable, coarse-to-fine sandy sediments of sandbars, sloughs, and mid-channel islands; and appears to be restricted to swiftly flowing water (Sickel 1980, p. 12). Sickel (1980, p. 12) characterized the habitat of the Altamaha spinymussel as coarse-to-fine-grain sandbars, and suggested that this may make the Altamaha spinymussel susceptible to adverse effects from sediment (siltation). Johnson (1970, p. 303) reported Altamaha spinymussels buried approximately 5.1 to 10.2 cm (2.0 to 4.0 in) below the substrate surface. While individual spinymussels have been found scattered throughout the upper Altamaha River, most of these sites have been clustered within 10 km (6 mi). From NatureServe (2015): The environmental specificity of this species is narrow. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls.

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory (inferred from NatureServe 2015)

Dispersal

Adult: Unknown (NatureServe 2015)

Dispersal/Migration Narrative

Adult: From NatureServe (2015): The Altamaha spinymussel is not as sedentary as most other freshwater mussels. This species is sometimes found in loose sandy substrates. It is capable of moving about in this substrate. Trails some 10+ meters long have been found. The Altamaha spinymussel moves about when the waters are covering the sand bars and long trails can be found as the water in the river drops. No one knows how far one mussel moves each year or exactly under what conditions this movement takes place.

Population Information and Trends

Population Trends:

Declining (USFWS 2011)

Resiliency:

Future Resiliency Within 20 years, it is possible that the Altamaha spinymussel could be extinct or functionally so if apparent population declines continue and reproduction and recruitment are unable to keep pace with adult mortality. However, if apparent declines are instead due at least in part to limited surveys and low detectability, and reproduction and recruitment are occurring, the species is likely to persist, though at low densities, in 1-2 populations beyond 20 years. The Ocmulgee/Altamaha population is likely to persist in this scenario, but there is uncertainty whether the Ohoopee population will persist as apparent densities are very low and the population was previously believed to have been extirpated but for the observation of a single spinymussel in 2005. Given that the species does not go extinct within 20 years, the Ohoopee population has opportunities to improve in resiliency under both the Status Quo and Conservation 50-year scenarios. The Ocmulgee/Altamaha population is likely to see no change in resiliency under the Status Quo scenario, but resiliency will improve under the Conservation scenario. The biggest increases in resiliency across multiple populations will occur if methods are successfully developed to propagate the Altamaha spinymussel in captivity and then use captive-bred mussels to reintroduce or augment populations in the wild. Without captive propagation, the two populations currently presumed extirpated will most likely remain so (USFWS, 2021)

Representation:

Future Representation As for the current condition, the Altamaha spinymussel is a narrow-ranging endemic species and we have no evidence for multiple representative units given the state of our current knowledge. Thus, future representation under all scenarios remains inherently low. This concludes our assessment of Altamaha spinymussel needs, current, condition, and future condition. There is a high degree of uncertainty in both the current and future condition of the species. Future assessments of this species' current and future condition can be improved by conducting a new range-wide survey for the species to better understand current abundance, habitat type utilization, and population trends, and increased research into its life history, especially its host fish. If populations are truly declining, as they appear to be based on available monitoring data, we need to better understand the threats driving this decline in order to develop specific conservation actions to counteract them. (USFWS, 2021)

Redundancy:

Future Redundancy Under the 20-year extinction scenario, redundancy will decline from 4 historical populations and 2 current populations to no remaining populations. If the species as a whole does not go extinct within 20 years, only 1-2 populations are predicted to remain after 50 years. The only way to increase redundancy compared to the current condition is with reintroductions from a successful captive propagation program. Based on our current knowledge of the biology and threats to the species, it is unlikely that the conservation actions included in the Conservation scenario without captive propagation are sufficient to enable natural recolonization of extirpated populations. However, increased research over the coming decades could reveal other conservation actions that target specific threats that are as yet undiscovered. (USFWS, 2021)

Number of Populations:

2 Extant populations (USFWS, 2024)

Population Narrative:

From USFWS (2011): The Altamaha spinymussel has been observed at only 22 sites since 2000, despite extensive survey efforts made by several different researchers. Recent surveys of the Ohoopee River and the analysis presented by Wisniewski et al. (2005) suggest that the species may still be declining. From NatureServe (2015): Estimated population size is 1000 - 25000 individuals. Loss of historical populations, decreased numbers of individuals at sites, increased threats make this species highly vulnerable. The Altamaha spinymussel is an endangered freshwater mussel endemic to the Altamaha River and its major tributaries in southeastern Georgia. Two of the four historic populations are presumed extirpated, and the other two have rapidly declined, with densities so low that surveys have failed to detect individuals in more than a decade (USFWS, 2024).

Threats and Stressors

Stressor: Present or threatened destruction, modification, or curtailment of habitat (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2011): Bogan (1993, pp. 599–600 and 603– 605) linked the decline and extinction of bivalves to a wide variety of threats including siltation, industrial pollution, municipal effluents, modification of stream channels, impoundments, pesticides, heavy metals, invasive species, and the loss of host fish. The Altamaha spinymussel lives within a large river drainage exposed to a variety of landscape uses. Habitat and water quality for the Altamaha spinymussel face degradation from a number of sources. Primary among these are threats from sedimentation and contaminants within the streams that the spinymussel inhabits.

Stressor: Inadequacy of existing regulatory mechanisms (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2011): Although BMPs for sediment and erosion control are often recommended or required by local ordinances for construction projects, compliance, monitoring, and enforcement of these recommendations are often poorly implemented. Furthermore, Georgia’s Erosion and Sediment Control Act exempts commercial forestry activities from the need to acquire permits and meet the minimum requirements of the Erosion and Sediment Control Act (Georgia’s BMPs for Forestry 2009, p. 64). In summary, some regulations exist that protect the species and its habitat; however, these regulations enforced by the State provide little direct protection of Altamaha spinymussel and only if protection of the spinymussel will not inhibit economic development. Nonpoint-source pollution is not regulated, and the Clean Water Act does not adequately protect the habitat from degradation caused by point-source pollutants.

Stressor: Water withdrawal (USFWS 2011)
Exposure:
Response:

Consequence:
Narrative: From USFWS (2011): Withdrawal of surface water within the Altamaha Basin for thermoelectric power generation, public water supplies, commercial industrial uses, and agriculture has a dramatic effect on flow rates (TNC 2004, p. 8). Within the Altamaha River Basin, 1,149 MGD was withdrawn for thermoelectric power generation in 1990 (Marella and Fanning 1990, pp. 14–17); water withdrawals of this magnitude can cause drastic flow reductions and alterations that may strand mussels on sandbars, resulting in mortality of individuals and harm to populations. In addition, low flow conditions provide access to the river margins and channels for all-terrain vehicles (ATV) and four-wheel drive vehicles (TNC 2004, p. 12; Stringfellow and Gagnon 2001, p. 3).

Stressor: Nonindigenous species (UFWS 2011)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2011): Nonindigenous species such as the flathead catfish and the Asian clam have been introduced to the Altamaha Basin and may be adversely affecting the Altamaha spinymussel. Since its introduction outside its native range, the flathead catfish has altered the composition of native fish populations through predation (Bourett et al. 2008, p. 413; Sakaris et al. 2006, p. 867; Sea Grant, 2006, p. 2; Pine et al. 2005, p. 902). The invasion of Asian clams in the Altamaha River has been accompanied by drastic declines in populations of native mussels, although it is unknown if the clams competitively excluded the mussels or simply colonized their habitat when they declined due to other factors (Gardner 1976, p. 124). Asian clams may pose a direct threat to native species through competition for available resources (space, minerals, or food), resulting in decline or local extirpation (Williams et al. 1993, p. 7; Bogan 1993, p. 605).

Stressor: Stochastic events (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2011): The linear nature of the Altamaha spinymussel’s habitat, reduced range, and very small population size make this species vulnerable to random detrimental or catastrophic events. Small, isolated populations may experience decreased demographic viability, increased susceptibility of extinction from stochastic environmental factors, and an increased threat of extinction from genetic isolation and subsequent inbreeding depression and genetic drift. Surviving populations of spinymussels are small, extremely localized, and vulnerable to habitat modification, toxic spills, progressive degradation from contaminants, and natural catastrophic changes to their habitats. Low numbers of individuals may also increase inbreeding and reduce genetic diversity (Lynch 1996, pp. 493–494).

Stressor: Climate change (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Climate change heightens the Altamaha spinymussel's vulnerability to extreme weather and may alter habitat suitability within its historical range. Emission scenarios predict a 1.5°C temperature increase in the first half of the 2030s and likely 2.0°C increase by the end of the 21st century, with intensified heatwaves and precipitation events (IPCC 2023). Higher

temperatures are projected to increase and will also likely increase chances of extreme drought (Frankson et al. 2022). Future precipitation trends for the southeast are uncertain, but projections suggest reduced annual precipitation and less frequent but stronger tropical storms (Carter et al. 2014). The southeastern United States will experience warmer temperatures, altered runoff, and increased drought frequency due to climate change, affecting water temperatures, flow, dissolved oxygen levels, and raising temperatures in stream systems (Poff et al. 2002). There is a natural inverse relationship between water temperature and dissolved oxygen, with increasing ambient temperature, our waters will also see increases in water temperature and a reduction in dissolved oxygen. This climate change changes to our aquatic systems will likely result in increased stress in the mussel and any host fish species and may potentially increase mortality of individuals (USFWS, 2024).

Recovery

Reclassification Criteria:
Recovery Priority Number: 5 (USFWS, 2023)

Delisting Criteria:
Criterion 1 (Redundancy and Resiliency) Through protection and augmentation of extant populations, successful establishment of reintroduced populations, and/or the discovery of additional populations, at least four populations exist: three high-resiliency populations persist in separate watersheds of the Altamaha basin and one additional moderate-resiliency population within its historical distribution. • Resiliency is assessed based on the condition of two population needs: species presence and recruitment, and three habitat needs: water quality, water quantity, and host fish community (Service 2021, p. 34). Levels of resiliency are further defined in section 4.2.6 of the SSA (Service 2021, p. 58). • Populations are shown to be persistent and reproducing or increasing through annual or biannual monitoring over at least a 10-year period. • If these include establishment of reintroduced populations, monitoring and modeling of species viability show stable or increasing occupancy of suitable habitat over at least a 10- year period without additional population augmentation (USFWS, 2023).

Criterion 2 (Resiliency) Each population in delisting criterion 1 exhibits evidence of recruitment, continued persistence, and positive or stable population trends through annual or biannual monitoring for at least 10 years. In addition, unaided recruitment equals or exceeds mortality over a projected 42-year span. • Longevity of Altamaha spinymussels is unknown but Elliptio spp. maximum age is known to range from 14 to 57 years (Haag and Rypel 2011); therefore, 42 years is the expected minimum time to complete 3 generations (USFWS, 2024).

Criterion 3 (Resiliency and Representation) Each population in delisting criterion 1 is supported by adequate flows, water quality, instream habitat, habitat connectivity and host fish communities are maintained at levels that meet life history requirements. • Adequate stream flows and water quality (e.g., thermal tolerances) needed to support the spinymussel and its host fishes are now defined by research. Long-term management is ensured through state and local management plans and regulations. • Habitats for Altamaha spinymussel and host fish communities are adequately connected as measured via gene flow among spinymussel populations. • When this requires active restoration of degraded habitat patches, measurable improvement to high-quality habitat (as defined by the primary constituents of Critical Habitat or subsequent research) for the Altamaha spinymussel is accomplished and larval recruitment is occurring (USFWS, 2023).

Recovery Actions:

- Recovery Priority Number: 5 (USFWS, 2019)
- RECOMMENDATIONS FOR FUTURE ACTIONS: A. A final, approved recovery plan with measurable criteria for the ASM should be developed (USFWS, 2019). B. Comprehensive survey efforts across ASM critical habitat should be conducted to adequately determine the current status of the ASM. Such surveys would provide updated occurrence and demographic (e.g. presence/absence of juveniles) data that could then be used to inform the other recommended future actions below (USFWS, 2019). C. Host fish identification efforts should be considered. If survey efforts reveal a stable population, the potential for conducting additional host fish trials should be explored. Additionally, using available fish occurrence data coupled with ASM historic and new survey data, the potential for drawing correlations between fish and ASM occurrence, or disappearance, at particular sites/river reaches should be explored (USFWS, 2019). D. Habitat quality, including substrate, temperature, and flow should be evaluated throughout ASM critical habitat. Where possible, current habitat quality data coupled with current ASM survey data should be evaluated to determine if any correlations exist between specific habitat quality parameters and ASM occurrence to further refine the expected ideal ranges of habitat quality parameters for the ASM (USFWS, 2019). E. Additional genetic analysis should be conducted to further explore the evolutionary history of the ASM and its phylogenetic relationships to other species to better inform management decisions and potential conservation actions (USFWS, 2019).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS A. A final, approved recovery plan with measurable criteria for the ASM should be developed. B. Comprehensive survey efforts across ASM critical habitat should be conducted to adequately determine the current status of the ASM. Such surveys would provide updated occurrence and demographic (e.g. presence/absence of juveniles) data that could then be used to inform the other recommended future actions below. C. Host fish identification efforts should be considered. If survey efforts reveal a stable population, the potential for conducting additional host fish trials should be explored. Additionally, using available fish occurrence data coupled with ASM historic and new survey data, the potential for drawing correlations between fish and ASM occurrence, or disappearance, at particular sites/river reaches should be explored. D. Habitat quality, including substrate, temperature, and flow should be evaluated throughout ASM critical habitat. Where possible, current habitat quality data coupled with current ASM survey data should be evaluated to determine if any correlations exist between specific habitat quality parameters and ASM occurrence to further refine the expected ideal ranges of habitat quality parameters for the ASM. E. Additional genetic analysis should be conducted to further explore the evolutionary history of the ASM and its phylogenetic relationships to other species to better inform management decisions and potential conservation actions. (USFWS, 2019)
- RECOMMENDED FUTURE ACTIVITIES In the upcoming years, priority activities include: • Conduct comprehensive range-wide surveys to assess the current population status of the Altamaha spinymussel. • Captive Propagation / Reintroduction / Augmentation Activities o Assess population status, size, genetic structure, and distribution. o Assess host species. o Assess use of in-vitro metamorphosis. o Identify and/or restore suitable sites for reintroduction. o Develop propagation plan. Detailed discussions on recovery actions and criteria are outlined in the Altamaha Spinymussel Recovery Plan (Service 2023a) and the Recovery Implementation Strategy (Service 2023b) (USFWS,

2024).

References

USFWS 2011. Endangered and Threatened Wildlife and Plants

Endangered Status for the Altamaha Spinymussel and Designation of Critical Habitat. 76 Federal Register 196. October 11, 2011. Pages 62928 - 62960. USFWS. 2023. Recovery Plan For Altamaha Spinymussel (Elliptio spinosa). Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 13 pp.

U.S. Fish and Wildlife Service. 2011. Endangered and Threatened Wildlife and Plants

Endangered Status for the Altamaha Spinymussel and Designation of Critical Habitat. Final rule. 76 FR 62928 - 62960 (October 11, 2011).

Endangered Status for the Altamaha Spinymussel and Designation of Critical Habitat. 76 Federal Register 196. October 11, 2011. Pages 62928 - 62960

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 17, 2016). USFWS. 2024. Altamaha Spinymussel (Elliptio spinosa) 5-Year Review: Evaluation and Summary. Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 11 pp. USFWS. 2023. Recovery Plan For Altamaha Spinymussel (Elliptio spinosa). Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 13 pp.

Endangered Status for the Altamaha Spinymussel and Designation of Critical Habitat. 76 Federal Register 196. October 11, 2011. Pages 62928 - 62960.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 17, 2016). USFWS. 2021. Species status assessment report for the Altamaha spinymussel (Elliptio spinosa), Version 1.0. June 2021. Atlanta, GA. 97 pp. USFWS. 2024. Altamaha Spinymussel (Elliptio spinosa) 5-Year Review: Evaluation and Summary. Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 11 pp.

USFWS. 2011. Endangered and Threatened Wildlife and Plants

USFWS. 2024. Altamaha Spinymussel (Elliptio spinosa) 5-Year Review: Evaluation and Summary. Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 11 pp.

USFWS. 2019. Altamaha spinymussel (Elliptio spinosa). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Field Office Coastal Georgia Suboffice Townsend, Georgia. 15 pp.

USFWS. 2019. Altamaha spinymussel (Elliptio spinosa). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Field Office Coastal Georgia Suboffice Townsend, Georgia. 15 pp.

USFWS. 2023. Recovery Plan For Altamaha Spinymussel (Elliptio spinosa). Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 13 pp.

USFWS. 2019. Altamaha spinymussel (Elliptio spinosa) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Field Office Coastal Georgia Suboffice Townsend, Georgia. 15 pp.

SPECIES ACCOUNT: *Elliptio steinstansana* (Tar River spinymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered; June 27, 1985; Southeast Region (R4) (USFWS 2014)

Physical Description

From USFWS (1992): Elliptio (Canthyria) steinstansana is a medium-sized mussel reaching about 60 millimeters (mm) in length (Johnson and Clarke 1983). The left valve contains two triangular pseudocardinal teeth. The right valve has two parallel pseudocardinals--one triangular and serrate (posterior) and one low and vestigial (anterior). The pallial line is impressed anteriorly and faint posteriorly, and nacre color is yellowish or pinkish (anterior) and bluish-white (posterior). Young specimens have an orange-brown periostracum with narrow and wide greenish rays; adults are darker, with inconspicuous rays. Elliptio steinstansana may be distinguished by its shiny periostracum, parallel pseudocardinal teeth, and the linear ridges on the inside surface of the shell.

Taxonomy

From USFWS (2014): Preliminary results from recent phylogeographic studies by Appalachian State University indicate that Tar River spinymussel is very closely related (i.e., putative sister taxa) to the James spinymussel (Pleurobema collina), and that both the Tar River spinymussel and James spinymussel likely belong to a genus other than Elliptio or Pleurobema (Perkins et al. 2014). This study also indicted historical gene flow between the Neuse and Tar populations of the Tar River spinymussel.

Historical Range

From (USFWS 1992): Elliptio (Canthyria) steinstansana has apparently always had a restricted distribution and is endemic to the Tar River drainage basin in eastern North Carolina. The type locality is the Tar River in Edgecombe County. Historically this species was collected only from the main stem of the Tar River from near Louisburg in Franklin County to the vicinity of Falkland in Pitt County (D. Stansbery, personal communication to Alderman, 1990; Shelley 1972; Clarke 1983). However, it is probable that E. steinstansana may have once occurred throughout much of the Tar River basin prior to settlement of the area during the 1700s.

Current Range

From USFWS (2014): Current available information indicates the species is endemic to both the Tar River and Neuse River systems in North Carolina. From NatureServe (2015): It is now limited to relatively small areas of these river basins with only one site remaining on a tributary of the lower Neuse River basin (Bogan, 2002).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

<u>Larvae:</u> From USFWS (2014): Host fish species that successfully transformed Tar River spinymussel glochidia in the lab are White shiner (Luxilus albeolus), Pinewoods shiner (Lythrurus

matutinus), Bluehead chub (Nocomis leptocephalus), and Satinfin shiner (Cyprinella analostana). Creek chub (Semotilus atromaculatus) and Swallowtail shiner (Notropis procne) were marginal hosts.

Reproduction Narrative

Adult: From USFWS (2014): Females are gravid from April to July and release conglutinates (packets of glochidia) and release up to four or five times during their brooding season (C Eads, pers. comm., 2010). From USFWS (1993): Details of the life history and ecological requirements of the Tar spinymussel are unknown. However, it probably follows one of the two life cycle strategies exhibited by all other North American unionids. Male mussels release sperm into the water column, and the sperm are taken in by females through their siphons during normal siphoning. Most native mussel species, including the genus Elliptio, generally exhibit the tachytictic mode of reproduction. Ortmann (1911) reported gravid females of Elliptio species from late April through early August. It is therefore likely that E. steinstansana is a tachytictic breeder.

Environmental Specificity

Adult: Narrow (inferred from USFWS 1993)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS 1993)

Habitat Narrative

Adult: From USFWS (2014): This species continues to have a very fragmented, relict distribution. Suitable habitat for the Tar River spinymussel appears to be extremely limited throughout the species' range. From USFWS (1993): The preferred habitat of E. steinstansana in Swift Creek was described by Alderman (1989) as relatively fast-flowing, well-oxygenated, circumneutral pH water in sites prone to significant swings in water velocity, with a substrate comprised of relatively silt-free, uncompacted gravel and/or coarse sand.

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dispersal/Migration Narrative

Adult: From NatureServe (2015): Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992).

Population Information and Trends

Population Trends:

Declining (USFWS 2014)

Adaptability:

Low (inferred from USFWS 2014)

Population Narrative:

From USFWS (2014): Monitoring and other surveys for the Tar River spinymussel have documented a continued decline in nearly all of the surviving populations of the species. Based on available survey data, all extant populations are extremely small in numbers and appear to be well below self-maintenance levels. No information is currently available concerning genetic health of the surviving populations.

Threats and Stressors

Stressor: Habitat fragmentation, loss, and alteration (USFWS 2014)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2014): There is evidence that all of the surviving populations continue to be threatened by many of the same factors identified in Service's revised recovery plan for the species as leading to the loss and decline of the species throughout significant portions of its historic range and threats to surviving populations, including habitat fragmentation, loss, and alteration resulting from impoundments, wastewater discharges, loss of forested lands and riparian buffers, and the runoff of silt and other pollutants from ground disturbance activities. Water quality continues to be an issue affecting habitat quality, as freshwater mussels are some of the most sensitive forms of aquatic life to toxicity of common pollutants in surface waters, such as ammonia, chlorine, chloride, copper, nickel, lead, potassium, sulfate, and zinc (Augspurger et al. 2003; Wang et al. 2007a, 2007b, 2010). Recent studies indicate that Tar River spinymussels are sensitive to contaminants (T Augspurger, pers. comm. 2014).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS 2014)
Exposure:
Response:
Consequence:
Narrative: From USFWS 2014): Many of the activities that pose a significant threat to the surviving populations of the Tar River spinymussel and its habitat are not subject to the regulations of section 7 of the Act because they do not have any federal involvement – no federal permits, federal authorization, or federal funding associated with the activity – and therefore no requirement for consultation with the Service if they may adversely affect federally-listed species. Accordingly, most of these activities occur without any coordination with the Service and are reviewed and regulated, if any review/regulation takes place, only by state and local regulatory agencies/governments for compliance with any applicable state and local regulations/ordinances1 . Neither the State of North Carolina nor the local governments with jurisdictions within the watersheds of streams supporting populations of the Tar River spinymussel, currently have regulations/ordinances that are adequate to protect the species from many of the adverse effects of agriculture, private forestry, and residential and commercial development activities (e.g., degradation or loss of riparian buffers; impacts to the streams'

hydrographs; stormwater runoff of sediments and other non-point source pollutants; wastewater discharges, etc.).

Stressor: Climate change (USFWS 2014)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2014): The multitude of effects of climate change has and will likely continue to impact the Tar River spinymussel. Many species of native freshwater 15 mussels are especially sensitive to climate change because of their patchy distribution, limited mobility, and dependence on host fish for their larval stage, as well as fragmentation of their ranges by habitat alteration (Newton and Lubeck 2013). Thermal regime change (e.g., higher temperatures) and habitat alteration/degradation (e.g., severe storm events and droughts) are climate change threats that aquatic species will face in the future (Pandolfo 2014). These changes can alter nutrient cycling, decrease habitat availability, decrease water quality, and possibly introduce parasites and pathogens into freshwater ecosystems (Pandolfo 2014 and references therein). Furthermore, climate change can alter species interactions and cause shifts in species distributions (Pandolfo 2014 and references therein).

Stressor: Drought (USFWS 2014)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2014): Streams supporting populations of the Tar River spinymussel have been affected by reoccurring drought conditions, including prolonged severe - exceptional drought conditions which persisted from the fall of 2006 through 2008 (NOAA 2008) – flow in reaches of several of the streams supporting the species was significantly reduced and in places completely dried up. In addition, from 2010-2012, Pandolfo (2014) found that temperatures in streams supporting the Tar River spinymussel reached thresholds that have been shown to cause harm to mussels in laboratory tests. These temperatures are also known to cause harm to several fish species, thus threatening the host-fish interaction with mussels.

Recovery

Reclassification Criteria:
1. All three existing populations of E. steinstansana in both the Tar River and Swift Creek show evidence of reproduction and recruitment; i.e., gravid females and host fish must be present and populations must contain at least two year classes, including one year class at age 4 or younger (USFWS 2014).

2. The reestablishment or the discovery of two additional viable populations has occurred (excluding the Tar River populations in Edgecombe and Nash Counties and the Swift Creek population). These populations should occur in two additional sections of the Tar River (or other streams if new information identifies them as historical habitat of the species), one each in Franklin and Pitt Counties, North Carolina -- areas historically supporting populations of E. steinstansana. A viable population is defined as a naturally reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural environmental changes. The number of individuals needed to reach a 5 viable population will be

determined as one of the recovery tasks. Each population should contain at least three subpopulation centers (a continuous river segment or a series of closely spaced river segments containing habitat and E. steinstansana as a breeding unit) dispersed such that a single catastrophic event would not eliminate the Tar spinymussel from newly reestablished locations. The subpopulation centers should be at least 1 river mile apart. These new subpopulations should also show evidence of reproduction and recruitment as described for criterion 1 (USFWS 2014).

3. The population units and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence (USFWS 2014).

4. Where habitat has been degraded, noticeable improvements in water and stratum quality have occurred (USFWS 2014).

5. Monitoring of all population units indicates no downward trends over a period of 15 to 20 years (USFWS 2014).

Recovery Actions:

- 1. Utilize existing legislation/regulations to protect the species (USFWS 1992).
- 2. Elicit support through development and utilization of an information/education program (USFWS 1992).
- 3. Search for new populations and monitor existing populations (USFWS 1992).
- 4. Determine species’ life history, habitat requirements, and threats to the species (USFWS 1992).
- 5. Implement management and alleviate threats to the species’ existence (USFWS 1992).
- 6. Through augmentation, reintroduction, and protection, establish five viable populations (USFWS 1992).
- 7. Develop and implement cryopreservation of the species (USFWS 1992).
- 1. Improve planning, coordination, and efficacy of recovery activities with key partners (e.g., NCWRC, NCDWR, NCNHP, USFWS, NRCS, local governments, local conservation NGOs, researchers, etc.) by meeting at least biennially to share information and review and recommend priority recovery actions (USFWS 2014).
- 2. Formalize a detailed population and habitat monitoring plan for all surviving populations (USFWS 2014).
- 3. Continue working with state and local governments to implement protective regulations/ordinances for addressing the impacts and threats from forestry, agriculture, development, and other land disturbance activities; wastewater discharges; and other impacts and threats to aquatic habitats within the streams supporting the Tar River spinymussel. One of the highest priorities is to continue working closely with state and local partners to develop, encourage public support for, and effectively implement protective water quality management strategies for the Tar River spinymussel such as protective stream designations and site-specific plans like the those required by North Carolina Procedures for Assignment of Water Quality Standards Rule 15A NCAC 02B .0110. In addition to addressing nonpoint source pollution, any strategy/plan should work to eliminate surface wastewater discharges from streams supporting the species. The strategy/plan should also result in implementation of regulations for water withdrawals that are protective of the streams’ hydrology, especially during periods of low flow (USFWS

2014).

- 4. Continue analyzing threats to the species and measures for off-setting these threats; determine species specific vulnerability to commonly discharged wastes (e.g. ammonia, chlorine) for which present discharge limits may not be protective of mussels (USFWS 2014).
- 5. Continue captive propagation efforts. Several of the extant populations are likely to become extirpated in the very near future. These populations represent a significant portion of the species' historic geographic range. Without immediate efforts through captive holding and propagation to maintain the genetic material from these populations for augmentation and reintroduction efforts, we may forever lose the genetic strains necessary for reestablishing these and other already extirpated populations of the species (USFWS 2014).
- 6. Work in coordination with federal and state agencies, knowledgeable biologists, and land stewards, using information about current water quality, fish and mussel assemblages, current watershed conditions, and prospective protective mechanisms to identify and evaluate candidate streams for potential reintroduction efforts and reintroduce/establish new populations were feasible. Because of their small size, amount of habitat degradation that has already occurred, existing land uses and degree of future threats, conservation of some of the extant populations in the streams they currently occupy is likely untenable. Immediate efforts should be undertaken to secure individuals from these populations and move them to captivity for propagation or refugia streams and use for reintroduction to suitable habitats. This would maintain the genetic diversity represented in these populations, while allowing for development of wild, viable populations within the species' historic range (USFWS 2014).
- 7. Continue habitat, life history, and captive propagation studies aimed at specific conservation applications, including: water temperature tolerances and optimal range; instream flow requirements, DO requirements, and specific impacts from altered flow regimes; support continued controlled propagation experiments with congeneric surrogates and permit work directly with Tar River spinymussel (USFWS 2014).
- 8. Continue working with partners to acquire land and establish conservation easements and restore forested buffers and instream habitat. Initially these efforts should be focused primarily on the best of the remaining populations of the Tar River spinymussel and areas targeted for population augmentation and/or reintroduction of the species (USFWS 2014).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Recommendations from the previous review (e.g., continuing propagation, protecting lands, ameliorating causes of habitat and species decline; USFWS 2014) remain relevant and should be referenced along with the recommendations that follow. These recommendations will promote recovery of Tar River Spinymussel over the next five years, and they align with several conservation objectives outlined for the species by the NCWRC (2018). Recommendations here are focused on protecting and restoring habitat, identifying and ameliorating pervasive threats, and promoting recovery through a rigorous propagation and reintroduction program. Preserve, improve, and restore aquatic and riparian habitats. Progress toward this goal would benefit from identification and conservation of targeted locations (i.e., mussel sanctuaries) in the Tar and Neuse River Basins that could serve as a foundation for recovery of Tar River Spinymussel and co-occurring listed and at-risk species. Such conservation corridors also could benefit neighboring communities by providing opportunities for compatible uses (e.g., scenic "blue trails" and improved water quality for recreation and subsistence). The Service will work with partners, including land trusts, state agencies, municipalities, and private landowners to acquire land, establish conservation easements, and restore riparian forests. Protecting land and restoring riparian habitats will remove, reduce, or mitigate threats. Multiple resources that highlight hotspots for conservation (e.g., Master et al. 1998; Smith et al. 2000; SALCC 2017) may be useful tools for identifying potential sanctuary areas that would promote recovery of Tar River Spinymussel. Reduce or remove threats to riparian and aquatic habitats on private lands. The vast majority of land is not in conservation holdings, and partnerships that promote responsible land management that protects water quality and aquatic habitats remain critical to the recovery of Tar River Spinymussel. A necessity for progress toward this goal is expanding public engagement to facilitate and improve awareness about Tar River Spinymussel (and co-occurring listed and at-risk species) among communities that live in the Neuse and Tar River watersheds. Collaborative conservation by landowners may help reduce existing threats (e.g., sedimentation and water quality issues); serve to mitigate impending threats (e.g., buffers from urbanization, stream shading to mitigate temperature extremes in a warming climate); and promote improved conditions to support Tar River Spinymussels released as part of population augmentation and reintroduction activities. Finalizing the Programmatic Safe Harbor Agreement currently being drafted between the Service and NCWRC will be important for relieving regulatory burden and promoting partnerships with landowners who are interested in engaging in activities that support aquatic habitat and species recovery. The Service will work with partners, including land trusts, state agencies, municipalities, and private landowners to reduce land use impacts on stream habitats (e.g., sedimentation) and water quality (e.g., pollution from runoff and discharges), both in the extant and historic ranges of Tar River Spinymussel so that remaining populations persist and augmentation/reintroduction activities will be successful. Examples of activities such partnerships could support include (but are not limited to): adhering to established best management practices (e.g., agricultural pesticide application/erosion control and timber management operations); restoring/maintaining riparian forests; eliminating disturbance in riparian areas and in-stream or streambank habitats; stormwater management to reduce runoff; adherence to existing water quality standards for permitted discharges; and improving wastewater treatment to remove contaminants. Identify and address factors limiting survival and persistence of wild populations and evaluate sites for reintroduction of Tar River Spinymussel. Progress toward this goal will improve our understanding of population decline, inform reintroduction activities, and support Recovery Criteria 1, 2, and 3. Restoring habitats for augmentation and reintroduction is critical for progress toward recovery. Identifying factors that have limited persistence in the Neuse River watershed would contribute to progress toward spatial recovery, as outlined in Recovery Criterion 2. However, evaluating sites for reintroduction in the Tar River watershed where wild populations more recently persisted also will be important for implementing reintroduction activities over the next five years. Successful reintroduction in many locations will be contingent on engagement and collaboration with local communities, where landowners may provide access to streams and other supportive measures. Based on existing knowledge of threats reported in this review and in previous assessments (USFWS 1992, 2014, 2019), important factors to investigate and address for site evaluation/restoration include physical habitat suitability, habitat stability, habitat connectivity, and water quality. Ecological factors that may affect Tar River Spinymussel persistence and merit attention include host fish considerations (e.g., habitat suitability for host fishes, mussel-host overlap) and the influence of invasive species (e.g., competition from Asian Clam, effects of Flathead Catfish on host fish populations). Continued monitoring of mussels that have already been released in augmentation activities will provide valuable data for some of these factors. Formalize and implement a propagation and reintroduction plan. The Service and the NCWRC are currently working on a draft propagation and reintroduction plan. Because reintroduction has been identified as a promising management strategy for recovery of Tar River Spinymussel, a rigorous plan is important for guiding the work. Formalizing such a plan is imperative for establishing goals, evaluating risks, planning and implementing monitoring to evaluate success and inform/trigger adaptive management, and ensuring continuity of the program (IUCN 2013). The plan should include elements that address captive propagation protocol and procedures to maximize production and improve juvenile survival (e.g., refining techniques; understanding effects of pathogens on production); and it should address wild and augmented/reintroduced population abundance, stability, and spatial distribution (i.e., Recovery Criteria 1 and 2). Implementation should include activities that will inform the species status based on recovery criteria for the next review. Examples include (but are not limited to): monitoring data on survival and population structure, information on genetic diversity of wild and released mussels (this also would address genetic concerns), and evidence of reproduction (e.g., intensive survey techniques that improve detection of juvenile mussels). (USFWS, 2020)

References

USFWS 2014. Tar River Spinymussel (Elliptio steinstansana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Raleigh Ecological Services Field Office Raleigh, North Carolina

U.S. Fish and Wildlife Service. 1992. Revised Tar Spinymussel Recovery Plan. Atlanta, GA. 34 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 17, 2016).

USFWS 2014. Tar River Spinymussel (Elliptio steinstansana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Raleigh Ecological Services Field Office Raleigh, North Carolina.

USFWS. 2014. Tar River Spinymussel (Elliptio steinstansana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Raleigh Ecological Services Field Office Raleigh, North Carolina.

U.S. Fish and Wildlife Service. 1992. Revised Tar Spinymussel Recovery Plan. Atlanta, GA. 34 pp.

USFWS 2014. Tar River Spinymussel (Elliptio steinstansana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Raleigh Ecological Services Field Office, Raleigh, North Carolina.

USFWS. 2020. Tar River Spinymussel (Parvaspina (=Elliptio) steinstansana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic–Gulf and Mississippi Basin Regions Raleigh Ecological Services Field Office Raleigh, North Carolina. 44 pp.

SPECIES ACCOUNT: *Elliptoideus sloatianus* (Purple bankclimber (mussel))

Species Taxonomic and Listing Information

Listing Status: Threatened; March 16, 1988; Southeast Region (R4)

Physical Description

From USFWS (2003): The purple bankclimber is a very large, heavy-shelled, strongly-sculptured mussel reaching lengths of 8.0 in (20.5 cm). A well-developed posterior ridge extends from the umbo to the posterior ventral margin of the shell. The posterior slope and the disk just anterior to the posterior ridge are sculptured by several irregular plications that vary greatly in development. The umbos are low, extending just above the dorsal margin of the shell. No sexual dimorphism is displayed in purple bankclimber shell characters. Internally, there is one pseudocardinal tooth in the right valve and two in the left valve. The lateral teeth are very thick and slightly curved, with one in the right valve and two in the left valve. Nacre color is whitish near the center of the shell becoming deep purple towards the margin, and very iridescent posteriorly.

Taxonomy

From USFWS (2003): This species is a member of the family Unionidae. Fuller and Bereza (1973) described aspects of its soft anatomy, and characterized Elliptoideus as being an “extremely primitive” genus. This taxon was originally described as Unio sloatianus Lea, 1840, and was included in the genus Elliptio until Frierson (1927) erected the subgenus Elliptoideus. The new subgenus designation was based on the presence of glochidia in all four gills instead of two gills, a characteristic of the genus Elliptio (Ortmann 1912).

Historical Range

From USFWS (2007): This sprecies histroically occurred in the Chattahoochee River in Alabama and Georgia; the Flint River in Georgia; the Apalachicola River in Florida; the Chipola River in Florida; and the Ochlocknee River in Georgia and Florida.

Current Range

This species is currently found in all of the histroical locations except the lower Chattahoochee Rvier (USFWS 2007). Apparently extirpated from the Chipola River, this species currently occurs sporadically in the Apalachicola, Flint, and Ochlockonee Rivers, and from single sites in the Chattahoochee River and a Flint River tributary (USFWS 2003).

Critical Habitat Designated

Yes; 11/15/2007.

Legal Description

On November 15, 2007, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the threatened purple bankclimber (Elliptoideus sloatianus) under the Endangered Species Act of 1973, as amended (72 FR 64286 - 64340).

Critical Habitat Designation

Critical habitat for the purple bankclimber (Elliptoideus sloatianus) are designated in Units 5, 6, 7, 8, 9, 10 in AL, FL, and GA.

Unit 5: Upper Flint River, Georgia. Unit 5 includes the main stem of the Flint River and eight of its tributaries upstream of Lake Blackshear, plus two tributaries that flow into Lake Blackshear, encompassing a total stream length of 380.4 km (236.4 mi) in Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia. The main stem of the Flint River in designated Unit 5 extends from the State Highway 27 bridge (Vienna Road) in Dooly and Sumter counties, Georgia (the river is the county boundary), upstream 247.4 km (153.7 mi) to Horton Creek in Fayette and Spalding counties, Georgia (the river is the county boundary). The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributary streams in Unit 5 are: Swift Creek, from Lake Blackshear upstream 11.3 km (7 mi) to Rattlesnake Branch in Crisp and Worth counties, Georgia (the creek is the county boundary); Limestone Creek, from Lake Blackshear in Crisp County, Georgia, upstream 8.8 km (5.5 mi) to County Road 89 in Dooly County, Georgia; Turkey Creek, from the Flint River upstream 21.7 km (13.5 mi) to Rogers Branch in Dooly County, Georgia; Pennahatchee Creek, from Turkey Creek upstream 4.8 km (3 mi) to Little Pennahatchee Creek in Dooly County, Georgia; Little Pennahatchee Creek, from Pennahatchee Creek upstream 5.8 km (3.6 mi) to Rock Hill Creek in Dooly County, Georgia; Hogcrawl Creek, from the Flint River upstream 21.6 km (13.4 mi) to Little Creek in Dooly and Macon counties, Georgia (the creek is the county boundary); Red Oak Creek, from the Flint River upstream 21.7 km (13.5 mi) to Brittens Creek in Meriwether County, Georgia; Line Creek, from the Flint River upstream 15.8 km (9.8 mi) to Whitewater Creek in Coweta and Fayette counties, Georgia (the creek is the county boundary); and Whitewater Creek, from Line Creek upstream 21.5 km (13.4 mi) to Ginger Cake Creek in Fayette County, Georgia. Unit 5 is designated for the shinyrayed pocketbook (Dinkins pers. comm. 1999, 2003; P.D. Johnson pers. comm. 2003; Brim Box and Williams 2000, p. 109–110; Roe 2000; L. Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); Gulf moccasinshell (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002; Brim Box and Williams 2000, p. 113–114; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); oval pigtoe (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002, 2003; Stringfellow pers. comm. 2000, 2003; Abbott pers. comm. 2001; Brim Box and Williams 2000, p. 116–117; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997); and purple bankclimber (Winterringer CCR pers. comm. 2003; Dinkins pers. comm. 2003; P.D. Johnson pers. comm. 2003; Albanese pers. comm. 2003 regarding unpub. data from De Genachete and CCR; Brim Box and Williams 2000, p. 105–106; E. Van De Genachete pers. comm. 1999). PCEs in Unit 5 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 6: Middle Flint River, Georgia. Unit 6 includes the main stem of the Flint River between Lake Worth (impounded by the Flint River Dam near Albany) and the Warwick Dam (which impounds Lake Blackshear), and nine tributaries, encompassing a total stream length of 302.3 km (187.8 mi) in Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia. The main stem of the Flint River in Unit 6 extends from Piney Woods Creek in Dougherty County, Georgia (the approximate upstream extent of Lake Worth), upstream 39.9 km (24.8 mi) to the Warwick Dam in Lee and Worth counties, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Middle Flint River in Unit 6 are: Kinchafoonee Creek, from the LeeDougherty county line (the approximate upstream extent of Lake Worth) upstream 107.6 km (66.8 mi) to Dry Creek in Webster County, Georgia; Lanahassee Creek, from Kinchafoonee Creek upstream 9.3 km (5.8 mi) to West Fork Lanahassee Creek in Webster County, Georgia; Muckalee Creek, from the Lee-Dougherty county line (the approximate upstream extent of Lake Worth) upstream 104.5 km (64.9 mi) to County Road 114 in Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km (4.5 mi) to Galey Creek in Schley County, Georgia; Mill Creek, from the Flint River upstream 3.2 km (2 mi) to Mercer Millpond Creek in Worth County, Georgia; Mercer Millpond Creek, from Mill Creek upstream 0.45 km (0.28 mi) to Mercer Millpond in Worth County, Georgia; Abrams Creek, from the Flint River upstream 15.9 km (9.9 mi) to County Road 123 in Worth County, Georgia; Jones Creek, from the Flint River upstream 3.8 km (2.4 mi) to County Road 123 in Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km (6.5 mi) to Dry Branch Creek in Lee County, Georgia. Unit 6 is designated for the shinyrayed pocketbook (Crow CCR pers. comm. 2004; Edwards Pittman Environmental 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; McCafferty pers. comm. 2000, 2001; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; BlalockHerod unpub. data 1997; Dinkins pers. comm. 1995; Brim Box and Williams 2000, p. 109–110), Gulf moccasinshell (Wisnewski unpub. data 2005; DeGarmo unpub. data 2002; Albanese pers. comm. 2003 regarding unpub. data from D. Shelton; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113– 114; Weston 1995), oval pigtoe (Wisnewski unpub. data 2005; Crow CCR pers. comm. 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; Stringfellow unpub. data 2002; Golladay unpub. data 2001, 2002; Brim Box and Williams 2000, p. 116–117; P. Johnson unpub. data 1999; Blalock-Herod unpub. data 1997; Weston 1995), and purple bankclimber (Tarbell 2004; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 6 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 7: Lower Flint River, Georgia. Unit 7 includes the main stem of the Flint River between Lake Seminole (impounded by the Jim Woodruff Lock and Dam) and the Flint River Dam (which impounds Lake Worth), and nine tributaries, encompassing a total stream length of 396.7 km (246.5 mi) in Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, GA. The main stem of the Flint River in Unit 7 extends from its confluence with Big Slough in Decatur County, GA (the approximate upstream extent of Lake Seminole) upstream 116.4 km (72.3 mi) to the Flint River Dam in Dougherty County, GA. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Lower Flint River in Unit 7 are: Spring Creek, from Smith Landing in Decatur County, Georgia (the approximate upstream extent of Lake Seminole), upstream 74.2 km (46.1 mi) to County Road 35 in Early County, Georgia; Aycocks Creek, from Spring Creek upstream 15.9 km (9.9 mi) to Cypress Creek in Miller County, Georgia; Dry Creek, from Spring Creek upstream 9.9 km (6.1 mi) to Wamble Creek in Early County, Georgia; Ichawaynochaway Creek, from the Flint River in Baker County, Georgia, upstream 68.6 km (42.6 mi) to Merrett Creek in Calhoun County, Georgia; Mill Creek, from Ichawaynochaway Creek upstream 7.4 km (4.6 mi) to County Road 163 in Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km (11.8 mi) to Little Pachitla Creek in Calhoun County, Georgia; Little Pachitla Creek, from Pachitla Creek upstream 5.8 km (3.6 mi) to Bear Branch in Calhoun County, Georgia; Chickasawhatchee Creek, from Ichawaynochaway Creek in Baker County, GA, upstream 64.5 km (40.1 mi) to U.S. Highway 82 in Terrell County, Georgia; and

Cooleewahee Creek, from the Flint River upstream 15.1 km (9.4 mi) to Piney Woods Branch in Baker County, Georgia. Unit 7 is designated for the shinyrayed pocketbook (Gangloff 2005; McCafferty pers. comm. 2004; Stringfellow unpub. data 2003; Dinkins pers. comm. 2001, 2003; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Albanese pers. comm. 2003 regarding unpub. data from CCR; Andrews pers. comm. 2000; BlalockHerod unpub. data 1997; Brim Box and Williams 2000, p. 109–110; Butler unpub. data 1993), Gulf moccasinshell (Abbott pers. comm. 2005; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113–114; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), oval pigtoe (Dinkins pers. comm. 2001; Golladay unpub. data 2001, 2002; Andrews pers. comm. 2000; Brim Box and Williams 2000, p. 116– 117; P. Johnson unpub. data 1999; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), and purple bankclimber (S. Carlson unpub. data 2002; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 7 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 8: Apalachicola River, Florida. Unit 8 includes the main stem of the Apalachicola River; two distributaries (channels flowing out of the main stem), and three tributaries, encompassing a total stream length of 155.4 km (96.6 mi) in Calhoun, Franklin, Gadsden, Gulf, Jackson, and Liberty counties, Florida. The main channel of the Apalachicola River in Unit 8 extends from the downstream end of Bloody Bluff Island (river mile 15.3 on U.S. Army Corps of Engineers Navigation Charts) in Franklin County, Florida, upstream to the Jim Woodruff Lock and Dam in Gadsden and Jackson counties, Florida (the river is the county boundary). The upstream extent of each distributary within the unit is its point of departure from the main channel of the Apalachicola River, and its downstream extent is the landmark listed. The two distributaries of the Apalachicola River in Unit 6 are: Chipola Cutoff, from the Apalachicola River in Gulf County, Florida, downstream 4.5 km (2.8 mi) to its confluence with the Chipola River in Gulf County, Florida; and Swift Slough, from the Apalachicola River in Liberty County, Florida, downstream 3.6 km (2.2 mi) to its confluence with the River Styx in Liberty County, Florida. The downstream extent of each tributary within the unit is its confluence (mouth) with the main channel of the Apalachicola River, and its upstream extent is the landmark listed. The three tributaries of the Apalachicola River within the unit are: River Styx from the mouth of Swift Slough in Liberty County, Florida, downstream 3.8 km (2.4 mi) to its mouth; Kennedy Slough from ¥85.07 longitude, 30.01 latitude in Liberty County, Florida, downstream 0.9 km (0.5 mi) to its confluence with Kennedy Creek; and Kennedy Creek from Brushy Creek Feeder (¥85.06 longitude, 30.01 latitude) in Liberty County, Florida, downstream 1.1 km (0.7 mi) to its mouth. Unit 8 is designated for the fat threeridge (Brim Box and Williams 2000, p. 92–93; Williams unpub. data 2000; Miller 1998, p. 54, 2000; Richardson and Yokley 1996, p. 137; Flakes 2001) and purple bankclimber (Brim Box and Williams 2000, p. 105– 106; Miller 1998, p. 55, 2000; Richardson and Yokley 1996, p. 137; Butler unpub. data 1993; Flakes 2001). PCEs in Unit 8 are vulnerable to impacts from sedimentation, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 9: Upper Ochlockonee River, Florida, Georgia. Unit 9 includes the main stem of the Ochlockonee River upstream of Lake Talquin (impounded by the Jackson Bluff Dam) and three tributaries, encompassing a total stream length of 177.3 km (110.2 mi) in Gadsden and Leon counties, Florida, and Grady and Thomas counties, Georgia. The main stem of the Ochlockonee River in Unit 9 extends from its confluence with Gulley Branch (the approximate upstream extent of Lake Talquin) in Gadsden and Leon counties, Florida (the river is the county boundary), upstream to Bee Line Road/County Road 306 in Thomas County, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The three tributary streams in Unit 9 are: Barnetts Creek, from the Ochlockonee River upstream 20 km (12.4 mi) to Grady County Road 170/ Thomas County Road 74 in Grady and Thomas counties, Georgia (the creek is the county boundary); West Barnetts Creek, from Barnetts Creek upstream 10 km (6.2 mi) to GA Highway 111 in Grady County, Georgia; and Little Ochlockonee River, from the Ochlockonee River upstream 13.3 km (8.3 mi) to Roup Road/County Road 33 in Thomas County, Georgia. Unit 9 is designated for the shinyrayed pocketbook (Blalock-Herod 2003, p. 1; McCafferty pers. comm. 2003; Williams unpub. data 1993), Ochlockonee moccasinshell (Brim Box and Williams 2000, p. 60; Williams and Butler 1994, p. 64), oval pigtoe (Edwards Pittman Environmental 2004; Blalock-Herod unpub. data 2003; Blalock-Herod 2003, p. 1; Williams unpub. data 1993), and purple bankclimber (Blalock-Herod unpub. data 2003; Blalock-Herod 2002, p. 1; Smith FDOT unpub. data 2001; Williams unpub. data 1993). PCEs in Unit 9 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 10: Lower Ochlockonee River, Florida. Unit 10 encompasses 75.4 km (46.9 mi) of the main stem of the Ochlockonee River from its confluence with Syfrett Creek in Wakulla County, Florida, upstream to the Jackson Bluff Dam (which impounds Lake Talquin) in Leon and Liberty counties, Florida. Unit 10 is designated for the purple bankclimber (Blalock-Herod unpub. data 2003; Williams unpub. data 1993). PCEs in Unit 10 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements of critical habitat are:

(i) A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);

(ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay;

(iii) Permanently flowing water;

(iv) Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387); and

(v) Fish hosts (such as largemouth bass, sailfin shiner, brown darter) that support the larval life stages of the seven mussels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on the effective date of this rule and not containing one or more of the primary constituent elements.

Activities in or adjacent to each of the critical habitat units may affect one or more of the PCEs that are found in the unit.

Management considerations to deal with sedimentation include protecting streams from sedimentation through application of agricultural and forestry best management practices, avoiding soiland vegetation-disturbing activity in the riparian zone, restoring unstable stream channels and other erosive areas, and other practices that prevent or reduce erosion.

Management considerations to deal with the threat of channel instability include avoiding soil- and vegetation-disturbing activity in the riparian zone, limiting impervious surface area, and other urban storm water runoff control methods. Sand and gravel mining (unit 3), dredging and channelization (unit 8), and dam construction (unit 5) may also affect channel stability.

Measures to deal with construction and operation of dams, water withdrawals, and water diversions include water conservation and operational strategies that manage water storage capacity and water demands in combination to minimize departures from the natural flow regime.

Management considerations to deal with the threat of pollution include applying agricultural and forestry best management practices, preserving native vegetation in riparian zones, maintaining septic systems, and taking other measures to minimize pollutantladen runoff to streams.

Life History

Feeding Narrative

Larvae: From USFWs (2003): The parasitic stage generally lasts a few weeks (Neves et al. 1985, O'Brien and Williams 2002) but possibly much longer (Yeager and Saylor 1995, Haag and Warren 1997), and is temperature dependent (Watters and O'Dee 2000). The eastern mosquitofish, blackbanded darter, guppy and greater jumprock transformed glochidia of the purple bankclimber during laboratory infections (O'Brien and Williams 2002, P.D. Johnson, Tennessee Aquatic Research Institute [TNARI], pers. comm. 2003). Only the eastern mosquitofish was effective at transforming glochidia (100 percent transformation rate), with the 51 percentages for the blackbanded darter and guppy being under 33 percent. Transformation on eastern mosquitofish occurred in 17 to 21 days at temperatures of 68.9 ± 5.4°F (O'Brien and Williams 2002). The primary host species for this mussel remains unknown (O'Brien and Williams 2002).

Juvenile: From USFWS (2003): Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Foods of juveniles up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). Growth rates for freshwater mussels tend to be relatively rapid for the first few years (Chamberlain 1931, Scruggs 1960, Negus 1966).

Adult: From USFW(2003): Adult freshwater mussels are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Mussels have been reported to consume detritus, diatoms, phytoplankton, zooplankton, and other microorganisms 44 (Coker et al. 1921, Churchill and Lewis 1924, Fuller 1974). Based on the findings of studies such as Baldwin and Newell (1991) and Neves et al. (1996), an omnivorous opportunistic diet would allow mussels to take advantage of whatever food type happens to be abundant. The relatively abrupt slowing in growth rate occurs at sexual maturity, probably due to energies being diverted from growth to gamete production.

Reproduction Narrative

Larvae: From USFWS (2003): Survival rates for a glochidium to metamorphosis ranges from 0.000001 to 0.0001 percent, not factoring in predation after metamorphosis (Watters and Dunn 1993-94).

Adult: From USFWS (2003): Host-specialist mussels without elaborate host-attractant mechanisms (e.g., amblemines) are dependent on densities of host fishes. Stable numbers of hosts therefore appear to be critical for determining where amblemines (e.g., purple bankclimber) are able to persist (Haag and Warren 1998). Females of the purple bankclimber with viable glochidia were found in the Ochlockonee River from February through April when water temperatures ranged from 46.4 to 59.0°F (O'Brien and Williams 2002). This indicates that it is a late winter-early spring releaser that may or may not be a parent overwintering species, dependent upon when fertilization takes place. Males expel sperm into the water column and females draw in sperm with the incurrent water flow. After a variable incubation period, mature glochidia, which may number in the tens of thousands to several million (Surber 1912, Coker et al. 1921, Yeager and Neves 1986), are expelled into the water column. Species in the subfamily Ambleminae are generally tachytictic.The age of sexual maturity for mussels is variable, usually requiring from three (Zale and Neves 1982) to nine (Smith 1979) years. No age specific information is available for this species. However, some related species were found to have individuals up to 24 and 56 years old, respectively (Moyer and Neves 1984).

Environmental Specificity

Adult: Narrow to moderate (NatureServe 2015)

Tolerance Ranges/Thresholds

Larvae: Low (see juvenile habitat narrative)

Juvenile: Low (USFWS 2003)

Adult: Low (USFWS 2003)

Habitat Narrative

Juvenile: From (USFWS (2003): Habitat and stream parameter preferences for juveniles are largely unknown (Neves and Widlak 1987). Neves and Widlak (1987) summarized stream parameter preferences of habitat, substrate, current velocity, and presence of other bivalves for juvenile unionids. Initially, juveniles were clumped in runs and riffles, occurred primarily behind boulders, and were significantly correlated with fingernail clam presence. They surmised that the habitat of older juveniles (i.e., ages 2 to 3 years) was similar to that of adults. The effects of heavy metals and other toxicants are especially profound on juvenile mussels (Robison et al. 1996), and on glochidia, which appear to be very sensitive to toxicants such as ammonia (Goudreau et al. 1993).

Adult: From USFWS (2003): Adult mussels are ideally found in localized patches (beds) in streams and almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The purple bankclimber inhabits small to large river channels in slow to moderate current over sand or sand mixed with mud or gravel substrates (Williams and Butler 1994). Over 80 percent of the specimens located during the ACF Basin portion of the status survey were found at sites with a substrate of sand/limestone (Brim Box and Williams 2000). ACF Basin collections were often in waters over 10 feet in depth. Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987). The environmental specificity of this species is narrow to moderate (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Larvae: Low (USFWS 2003)

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory (NatureServe 2015)

Dispersal

Larvae: Low - fish movement over 21 days (USFWS 2003)

Dependency on Other Individuals or Species for Dispersal

Larvae: Host fish (USFWS 2003)

Dispersal/Migration Narrative

Larvae: USFWS (2003): Parasitism serves as a means of dispersal for this relatively sedentary group (Neves 1993).

Adult: From NatureServe (2014): Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate although some passive movement downstream may occur during high flows.

Population Information and Trends

Population Trends:

Stable (USFWS 2007)

Number of Populations:

5 (see current range/distribution)

Population Size:

2,500 - 100,000 (NatureServe 2015)

Population Narrative:

From USFWS (2007): Species status is stable; populations have persisted over the year. There are 34 subpopulations within the five rivers this species inhabits. From USFWS (2003): The restricted distribution of these seven species also makes localized subpopulations susceptible to adverse habitat and water quality alterations, toxic chemical spills, and the deleterious effects of genetic isolation. Overall, 34 subpopulations of purple bankclimber currently persist.The population size is estimated to be between 2,500 and 100,000 individuals (NatureServe 2015).

Threats and Stressors

Stressor: Present of threatened destruction, modification, or curtailment of habitat (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2007): The declining range and abundance is mostly due to changes in riverine habitat resulting from dams, dredging, mining, channelization, pollution, sedimentation, and water withdrawals. Sedimentation and water pollution continue to be an almost ubiquitous threat in the range of this mussel. The construction and operation of dams, water withdrawals, and water diversions may alter features of the flow regime important to this species and it host fishes. Sand and gravel mining, dredging, and channelization also affect channel stability and improper road crossing structures may prevent passage of fish hosts.

Stressor: Non-indigenous species (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: From USFWS 2007: Flathead catfish and blue catfish have been introduced in the ACF. These fishes are known to consume mussels and fishes and negatively impact fish populations that may be hosts for endangered unionids. Monitoring data from FWS indicate that populations of redbreast sunfish, snail and spotted bullhead catfish, and other species have declined since the late 1980s, which may be the result of predation by the flathead catfish (T. Hoehn, pers comm.).

Stressor: Insufficient host fish densities (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2007): Riverine fish populations in the Southeast generally have been adversely affected by a variety of the same habitat alterations that have contributed to the decline of the region's mussel fauna (Etnier 1997; Neves et al. 1997; Warren et al. 1997).

Recovery

Delisting Criteria:
Biennial monitoring shows that an increase of the current number of subpopulation/sites and extent of occurrence is enough to ensure population viability, reduce isolation among populations, and increase the potential for genetic exchange (USFWS 2007).

1. Populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes. 1a) At least seven (7) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (USFWS, 2019).

2. The spatial distribution of populations (as described in Criterion 1) are sufficient to protect against extinction from catastrophic events and maintain adaptive potential. 2a) At least one (1) population in each of the Chipola, Flint, Apalachicola, and Ochlockonee River systems (USFWS, 2019).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (USFWS, 2019).

Recovery Actions:

- 1. Secure extant subpopulations and currently occupied habitats and ensure subpopulation viability (USFWS 2003).
- 2. Search for additional subpopulations of the species and suitable habitat (USFWS 2003).
- 3. Determine through research and propagation technology the feasibility of augmenting extant subpopulations and reintroducing or reestablishing the species into historical habitat (USFWS 2003).
- 4. Develop and implement a program to evaluate efforts and monitor subpopulation levels and habitat conditions of existing subpopulations, as well as newly discovered, reintroduced, or expanding subpopulations (USFWS 2003).
- 5. Develop and utilize a public outreach and environmental education program (USFWS 2003).
- 6. Assess the overall success of the recovery program and recommend actions (USFWS 2003).
- 1. The subpopulation recovery criteria defining a subpopulation as a site is vague and less meaningful than actual density or population estimates. As USFWS acquires more information about population characteristic, USFWS should revise recovery criteria. The USFWS recommends using quantitative methods to monitor changes in population size with each sub-basin (USFWS 2007).
- 2. Define "viable subpopulation" through implementation of Recovery Tasks 1.3.6, 1.3.7, and 1.3.8 (USFWS 2007).
- 3. Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders (USFWS 2007).
- 4. Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies (USFWS 2007).
- 5. Work with the EPA and States to modify numerical water quality criteria for ammonia and copper (USFWS 2007).
- 6. Develop and implement a program to monitor subpopulation levels and habitat conditions of existing subpopulations (USFWS 2007).
- 7. Continue re-evaluating threats to these mussels (USFWS 2007).

References

USFWS 2007. Fat Three ridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus penicillatus) Ochlocknee Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

U.S. Fish and Wildlife Service. 2003. Recovery Plan for Endangered Fat Threeridge (Amblema neislerii), Shinyrayed Pocketbook (Lampsilis subangulata), Gulf Moccasinshell (Medionidus penicillatus), Ochlockonee Moccasinshell (Medionidus simpsonianus), and Oval Pigtoe (Pleurobema pyriforme)

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp.

U.S. Fish and Wildlife Service. 2007. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Final rule. 72 FR 64286 - 64340 (November 15, 2007).

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 18, 2016).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 18, 2016). U.S. Fish and Wildlife Service. 2019 Amendment 1 to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Gulf Moccasinshell (Medionidus penicillatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elliploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata).

USFWS. 2007. Fat Three ridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus penicillatus) Ochlocknee Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

U.S. Fish and Wildlife Service. 2019 Amendment 1 to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Gulf Moccasinshell (Medionidus penicillatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elliploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata).

USFWS 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office, Panama City, Florida.

SPECIES ACCOUNT: *Epioblasma brevidens* (Cumberlandian combshell)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Cumberlandian combshell has a thick solid shell with a smooth to clothlike periostracum, which is yellow to tawny brown in color with narrow green broken rays. The nacre is white. The shells of females are inflated, with serrated teethlike structures along a portion of the shell margin.

Taxonomy

The broad, yellowish shell with broken rays and the distinctive marsupial expansion of the female distinguish this species from most other mussels in the range except Pychobranchus fasciolaris [(Rafinesque, 1820), the kidneyshell] and Epioblasma lenoir (Lea, 1842) [narrow catspaw]. Male E. brevidens are broader than P. fasciolaris and the females of the latter species do not exhibit the marsupial development of the former. Raying patterns on P. fasciolaris usually are not developed. Epioblasma lenoir is a considerably smaller species, has a much lighter shell, tends to be greenish, does not have as developed a marsupial expansion, and probably is extinct.

Historical Range

Historically, it ranged throughout the Cumberlandian Region, occurring in three physiographic provinces (i.e., Interior Low Plateau, Cumberland Plateau, Ridge and Valley) and five states (i.e., Alabama, Kentucky, Mississippi, Tennessee, Virginia). In the Cumberland River it occurred from the base of Cumberland Falls, McCreary and Whitley Counties, Kentucky, downstream to Stewart County, Tennessee. In the Tennessee River, it occurred throughout the main stem, downstream to Benton and Humphreys Counties, Tennessee. The Cumberlandian combshell also occurred in numerous tributaries in the Cumberland and Tennessee River systems. The most downstream records in both rivers are from archeological sites (Parmalee and Bogan 1998), indicating that at least in premodern times this species occurred further downstream from the area strictly defined as the Cumberlandian Region. The Cumberlandian combshell has been extirpated from a large percentage of its former range. Main-stem populations in both the Cumberland and Tennessee Rivers are now considered extirpated (Ahlstedt, pers. comm., 2003). This species has apparently also been eliminated from numerous tributaries in the Cumberland River system (e.g., Rockcastle River, Beaver Creek, Obey River, Caney Fork, Stones River, Red River) and the Tennessee River system (e.g., Station Creek, Wallen Creek, Holston River, Nolichucky River, West Prong Little Pigeon River, Little Tennessee River, Paint Rock River, Elk River, Little Bear Creek, Cedar Creek, Duck River). The Cumberlandian combshell has also been extirpated from large portions of additional tributaries in the Cumberlandian Region (e.g., Clinch River, Powell River, North Fork Holston River, Bear Creek).

Current Range

Extant Cumberland River system populations occur in Buck Creek, Pulaski County, Kentucky; and Big South Fork, Scott County, Tennessee, and McCreary County, Kentucky. In the Tennessee River system, populations are thought to remain in the Clinch River, Scott County, Virginia, and Hancock County, Tennessee; Powell River, Lee County, Virginia, and Claiborne and Hancock

Counties, Tennessee; and Bear Creek, Colbert County, Alabama, and Tishimingo County, Mississippi. Although the species was found in Alabama in Cedar Creek (tributary to Bear Creek) in 1988, a recent survey of the entire Bear Creek system failed to reveal even shells of the Cumberlandian combshell at nine sites in Cedar Creek (McGregor and Garner, in press).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 8/31/2004.

Legal Description

On August 31, 2004, the U.S. Fish and Wildlife designated critical habitat for the endangered Cumberlandian combshell (Epioblasma brevidens) under the Endangered Species Act of 1973, as amended (69 FR 53136 - 53180).

Critical Habitat Designation

Critical habitat for the Cumberlandian combshell (Epioblasma brevidens) is designated in Units 1, 2, 4, 5, 6, 9, and 10; in AL, KY, MS, TN, and VA.

Unit 1. Duck River, Maury and Marshall Counties, Tennessee Unit 1 encompasses 74 rkm (46 rmi) of the main stem of the Duck River channel from rkm 214 (rmi 133) (0.3 rkm (0.2 rmi) upstream of the First Street Bridge in the City of Columbia, Maury County, Tennessee, upstream to Lillard Mill Dam at rkm 288 (rmi 179), Marshall County, Tennessee. This reach of the Duck River contains a robust, viable population of the oyster mussel (Ahlstedt 1991b; Gordon 1991; S.A. Ahlstedt, pers. comm. 2002) and historically supported the Cumberlandian combshell (Hinkley and Marsh 1885; Ortmann 1925; Isom and Yokley 1968; van der Schalie 1973; Gordon 1991). Approximately 59 percent of this Unit is now bounded by the YWMA (recently transferred from the TVA to TWRA).

Unit 2. Bear Creek, Colbert County, Alabama, and Tishomingo County, Mississippi. Unit 2 encompasses 40 rkm (25 rmi) of the main stem of Bear Creek from the backwaters of Pickwick Lake at rkm 37 (rmi 23), Colbert County, Alabama, upstream through Tishomingo County, Mississippi, ending at the Mississippi/ Alabama State line. Recent mussel surveys in the Mississippi section of Bear Creek confirmed that the Cumberlandian combshell is still extant (R.M. Jones, pers. comm. 2002), and continues to be present in the Colbert County, Alabama portion of the unit (Isom and Yokley 1968; McGregor and Garner 2004). Bear Creek is in the historical range of the oyster mussel (Ortmann 1925).

Unit 4. Powell River, Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia. Unit 4 encompasses 154 rkm (94 rmi) and includes the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. This reach is currently occupied by the Cumberlandian combshell (Ahlstedt 1991b; Gordon 1991) and rough rabbitsfoot (Service 2004), and was historically occupied by the oyster mussel (Wolcott and Neves 1990) and the purple bean (Ortmann 1918). It is also existing critical habitat for the federally listed slender chub and yellowfin madtom (see ‘‘Existing Critical Habitat’’ and Table 3).

Unit 5. Clinch River and tributaries, Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia. Unit 5 totals 272 rkm (171 rmi), including 242 rkm (148 rmi) of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia; 4 rkm (2.5 rmi) of Indian Creek from its confluence with the Clinch River upstream to the fourth Norfolk Southern Railroad crossing at Van Dyke, Tazewell County, Virginia; and 21 rkm (13 rmi) of Copper Creek from its confluence with the Clinch River upstream to Virginia State Route 72, Scott County, Virginia. The Clinch River main stem currently contains the oyster mussel, rough rabbitsfoot, Cumberlandian combshell, and purple bean (Gordon 1991; Ahlstedt and Tuberville 1997; S.A. Ahlstedt, pers. comm. 2002). Indian Creek currently supports populations of the purple bean and rough rabbitsfoot (Winston and Neves 1997; Watson and Neves 1996). Copper Creek is currently occupied by a low-density population of the purple bean and contains historical records of both the oyster mussel and rough rabbitsfoot (Ahlstedt 1981; Fraley and Ahlstedt 2001; S.A. Ahlstedt, pers. comm. 2003). Copper Creek is critical habitat for the yellowfin madtom and a portion of the Clinch River main stem section is critical habitat for both the slender chub and the yellowfin madtom.

Unit 6. Nolichucky River, Hamblen and Cocke Counties, Tennessee. Unit 6 includes 8 rkm (5 rmi) of the main stem of the Nolichucky River and extends from rkm 14 (rmi 9) (approximately 0.6 rkm (0.4 rmi) upstream of Enka Dam to Susong Bridge in Hamblen and Cocke counties, Tennessee. The Nolichucky River currently supports a small population of the oyster mussel (S.A. Ahlstedt, pers. comm. 2002) and was historically occupied by the Cumberlandian combshell (Gordon 1991).

Unit 9. Big South Fork and Tributaries, Fentress, Morgan, and Scott Counties, Tennessee, and McCreary County, Kentucky. Unit 9 encompasses 153 rkm (95 rmi) and consists of 43 rkm (27 rmi) of the Big South Fork of the Cumberland River main stem from its confluence with Laurel Crossing Branch downstream of Big Shoals, McCreary County, Kentucky, upstream to its confluence with the New River and Clear Fork, Scott County, Tennessee; 11 rkm (7 rmi) of North White Oak Creek from its confluence with the Big South Fork upstream to Panther Branch, Fentress County, Tennessee; 14.5 rkm (9.0 rmi) of the New River from its confluence with Clear Fork upstream to U.S. Highway 27, Scott County, Tennessee; 40 rkm (25 rmi) of Clear Fork from its confluence with the New River upstream to its confluence with North Prong Clear Fork, Morgan and Fentress Counties, Tennessee; 10 rkm (6 rmi) of White Oak Creek from its confluence with Clear Fork upstream to its confluence with Bone Camp Creek, Morgan County, Tennessee; 6 rkm (4 rmi) of Bone Camp Creek from its confluence with White Oak Creek upstream to Massengale Branch, Morgan County, Tennessee; 14.5 rkm (9.0 rmi) of Crooked Creek from its confluence with Clear Fork upstream to Buttermilk Branch, Fentress County, Tennessee; and 14.5 rkm (9 rmi) of North Prong Clear Fork from its confluence with Clear Fork upstream to Shoal Creek, Fentress County, Tennessee. The main stem of the Big South Fork currently supports the Cumberland elktoe and the best remaining Cumberlandian combshell population in the Cumberland River System (Bakaletz 1991; Gordon 1991; R.R. Cicerello, pers. comm. 2003). The main stem of the Big South Fork historically contained the oyster mussel (S.A. Ahlstedt, pers. comm. 2002; Service 2004). The Epioblasma mussel that currently inhabits the Big South Fork main stem, and that is occasionally referred to as the oyster mussel, is now recognized as a sister species of the tan riffleshell (see ‘‘Taxonomy, Life History, and Distribution’’ section) (Service 2004; J. Jones, pers. comm. 2003). The remainder of the unit contains habitat currently occupied by the Cumberland elktoe (Call and Parmalee 1981; Bakaletz 1991; Gordon

1991). The largest population of Cumberland elktoe in Tennessee is in the headwaters of the Clear Fork System (Call and Parmalee 1981; Bakaletz 1991). The Big South Fork and its many tributaries may actually serve as habitat for one large interbreeding population of the Cumberland elktoe (Service 2004).

Unit 10. Buck Creek, Pulaski County, Kentucky. Unit 10 encompasses 58 rkm (36 rmi) and includes Buck Creek from the State Route 192 Bridge upstream to the State Route 328 Bridge in Pulaski County, Kentucky. Buck Creek is currently occupied by the Cumberlandian combshell (Gordon 1991; Hagman 2000; R.R. Cicerello, pers. comm. 2003) and historically supported the oyster mussel (Schuster et al. 1989; Gordon 1991). This unit is adjacent to the DBNF.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the Cumberlandian combshell (Epioblasma brevidens) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the five mussels and their host fish;

(ii) Geomorphically stable stream and river channels and banks;

(iii) Stable substrates consisting of mud, sand, gravel, and/or cobble/ boulder, with low amounts of fine sediments or attached filamentous algae;

(iv) Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and

(v) Fish hosts with adequate living, foraging, and spawning areas for them.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, or presence of fish hosts. All of these units are threatened by actions that alter the stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); and point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation. Habitat fragmentation, population isolation, and small population size compounds these threats to the species. Various activities in or adjacent to each of the critical habitat units may affect one or more of the primary constituent elements that are found in the unit.

Life History

Feeding Narrative

Larvae: The Cumberlandian combshell is dependent on a host.

Juvenile: Juvenile mussels employ foot (pedal) feeding and are thus suspension/deposit feeders (Yeager et al. 1994). The juvenile diet (up to 2 weeks of age) includes bacteria, algae (i.e., nonfilamentous, non-blue green), and diatoms, with some detrital and inorganic colloidal particles (Yeager et al. 1994).

Adult: Adult freshwater mussels are filter feeders, orienting themselves in the substrate tofacilitate the siphoning of the water column for oxygen and food (Kraemer 1979).Specific food habits of the oyster mussel is unknown, but they likely ingest food itemssimilar to those consumed by other riverine mussels. Mussels are known to consumebacteria, detritus, assimilated organic material, diatoms, phytoplankton, zooplankton,phagotrophic protozoans, and other microorganisms (Coker et al. 1921, Churchill andLewis 1924, Ukeles 1971, Fuller 1974, Baldwin and Newell 1991, Neves et al. 1996).

Reproduction Narrative

Adult: Spawning in the lampsiline Cumberlandian combshell occurs in late summer (Gordon 1991). Females display until the water temperature drops below approximately 50°F in the fall, burrow into the substrate to overwinter, and begin displaying again as early as March (Jones, pers. comm., 2003). Gravid females, qualitatively estimated at 8 to 13 years of age, have been reported from early May to June at water temperatures of 59.0° to 64.0°F (Ahlstedt 1991a, Yeager and Saylor 1995). The female has a complex mantle display that resembles the cercae of insect larvae (e.g., stoneflies) protruding from under two or three small stones (Jones, pers. comm., 2003). One of its host fishes, the logperch (Percina caprodes), has the peculiar habit of flipping small stones in search of food (Etnier and Starnes 1993). Glochidial release generally is complete by mid-June (Jones, pers. comm., 2002). Several other native host fish species have been identified, including the wounded darter, redline darter, bluebreast darter, snubnose darter (E. simoterum), greenside darter (E. blennioides), banded sculpin, black sculpin, and mottled sculpin(Yeager and Saylor 1995; Jones and Neves, unpub. data). Transformation took from 16 to 48 days, at 60.4° to 62.4°F (Yeager and Saylor 1995).

Geographic or Habitat Restraints or Barriers

Larvae: impoundments

Juvenile: impoundments

Adult: impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; Requires host

Juvenile: Moderate; Generalist or community with some key requirements scarce

Adult: Moderate; Generalist or community with some key requirements scarce

Tolerance Ranges/Thresholds

Larvae: low; sensitive to water quality degradation

Juvenile: low; sensitive to water quality degradation

Adult: low; sensitive to water quality degradation

Site Fidelity

Larvae: dependent on host

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Adult mussels are ideally found in localized patches (beds) in streams, almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Vannote and Minshall 1982, Neves and Widlak 1987, Leff et al. 1990, Strayer 1997). Physical qualities of the sediment (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediment, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999). Water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams (Huehner 1987). The Cumberlandian combshell inhabits medium-sized streams to large rivers on shoals and riffles in coarse sand, gravel, cobble, and boulders (Dennis 1985, Gordon 1991). It is not associated with small stream habitats (Dennis 1985) and tends not to extend as far upstream in tributaries. In general, it occurs in larger tributaries than does its congener the oyster mussel. Gordon (1991) states that the species prefers depths less than 3 feet, but it appears to persist in the deep-water areas of the Old Hickory Reservoir on the Cumberland River, where there is still fairly strong flow from the Cordell Hull and Center Hill Reservoirs (Gordon and Layzer 1989).

Dispersal/Migration

Motility/Mobility

Larvae: Yes via host

Juvenile: Limited; Unless flushed by strong flows

Adult: Limited; Unless flushed by strong flows

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Dependent on host

Juvenile: Non-migratory

Adult: Non-migratory

Dispersal

Larvae: dependent on host

Juvenile: Limited; passive movement via flushing event

Adult: Limited; passive movement via flushing event

Dependency on Other Individuals or Species for Dispersal

Larvae: yes; host

Dispersal/Migration Narrative

Larvae: Primary dispersal of the Cumberlandian combshell is likely via through host.

Juvenile: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Adult: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Population Information and Trends

Population Trends:

Stable (USFWS, 2019)

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

1 to 5

Population Size:

50 - 2500 individuals

Minimum Viable Population Size:

unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Historically, the Cumberlandian combshell appears to have been widespread and common at many sites in larger Cumberlandian Region streams, but has been extirpated from a large portion of its range. Neel and Allen (1964) reported it as being “very common” in the upper Cumberland River below Cumberland Falls in the late 1940s. Ortmann (1924a, 1925) reported it as relatively abundant in the upper Tennessee River system but rare in the lower Tennessee and Cumberland River systems. Stable. Extant populations continue to occupy portions of the Big South Fork Cumberland River (Big South Fork) (Kentucky and Tennessee), Clinch River (Tennessee and Virginia), Powell River (Virginia), Buck Creek (Kentucky), and Bear Creek (Alabama and Mississippi). The largest and most viable populations of the Cumberlandian Combshell occur in the Big South Fork and Clinch River, where the species occurs in low to moderate densities (0.01-0.40 mussels/m2), with multiple age classes represented (evidence of recruitment). The Service and its partners continue to work on augmentation of extant populations and have initiated several reintroduction projects, resulting in new populations in the Duck River (Tennessee), Elk River (Tennessee), Nolichucky River (Tennessee), and Rockcastle River (Kentucky). (USFWS, 2019)

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The decline, extirpation, and extinction of mussel species is overwhelmingly attributed to habitat alteration and destruction (Neves 1993), primarily manifest in the conversion of riverine systems to impoundments (Yeager 1993 1994). Impoundments, especially large main-stem reservoirs, have significantly altered riverine ecosystems (Baxter and Glaude 1980, Williams et al. 1992, Allan and Flecker 1993, Ligon et al. 1995, Sparks 1995) and have been a major factor in the high extinction rate oof freshwater mollusks (Johnson 1978, Lydeard and Mayden 1995, Neves et al. 1997). Impoundments result in the elimination of riffle and shoal habitats and the subsequent loss of mussel resources (Ortmann 1925; van der Schalie 1938; Scruggs 1960; Bates 1962; Neel 1963; Isom 1969, 1971; Stansbery 1970, 1973b; Fuller 1974; Schmidt et al. 1989; Williams et al. 1992; Layzer et al. 1993; Parmalee and Hughes 1993; Lydeard and Mayden 1995; Sickel and Chandler 1996; Watters 1996). Most of a river’s ecological processes are also disrupted, for example, by modifying flood pulses; controlling impounded water elevations; increasing depth; decreasing habitat heterogeneity; altering water flow, sediment, nutrients, energy input and output, and the riverine biota; and causing the loss of bottom stability due to subsequent sedimentation (Williams et al. 1992, Ligon et al. 1995, Sparks 1995, Watters 2000). The elimination of current and the covering of rocky and sand substrates by fine sediments alters the habitat of riverine species (including these five, typically shoal-inhabiting, species) to the

point where they can no longer reproduce, recruit, and survive under impoundment conditions (Fuller 1974, Neves et al. 1997, Hughes and Parmalee 1999). In addition, dams can seriously alter downstream water quality and riverine habitat (Allan and Flecker 1993, Ligon et al. 1995, Collier et al. 1996) and negatively impact mussel populations in tailwaters (Cahn 1936b, Hickman 1937, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999, McMurray et al. 1999b, Vaughn and Taylor 1999). These changes include thermal alterations (Neves 1993), channel characteristics, habitat availability, and flow regimes that have drastic effects on the stream biota (Krenkel et al. 1979, Allan and Flecker 1993). Altered effects also include fish community shifts (Brim 1991) and the resultant colonization by fewer native species and more alien species (Williams and Neves 1992). Daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, cold-water releases, turbulence, high silt loads, and altered host fish distribution have contributed to limited mussel recruitment and skewed demographics (Sickel 1982, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, McMurray et al. 1999b). Cold-water releases from large nonnavigational dams are the result of placing water intake structures low on the dam to increase hydropower efficiency (Krenkel et al. 1979). The release of cold water and scouring of the riverbed from highly fluctuating, turbulent flows in tailwaters have also been implicated in the demise of Cumberlandian Region mussel faunas (Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999). Specifically, tachytictic species, which depend on warm summer temperatures to initiate gametogenesis, spawning, glochidia release, and the proper host fish being present, experience reproductive failure below dams (Heinricher and Layzer 1999). Bradytictic species are also negatively affected, and the decline of mussel populations has been manifested over a period of several decades (Neves 1999a). The mussel faunas of the middle Cumberland, lower Obey, lower Caney Fork, Little Tennessee, and Elk Rivers have been profoundly impacted by cold-water releases, including populations of the Cumberlandian combshell and oyster mussel. A reduction in water temperature, rapid changes in flow releases during hydropower peaking events, and the resultant bank sloughing and channel scouring have altered habitats so profoundly below hydroelectric dams that riverine species, including these five mussels, are unable to reproduce, recruit, and survive such conditions. The entire length of the main stems of the Tennessee and Cumberland Rivers and many of their largest tributaries are now impounded or greatly modified by the discharge of tailwaters. More than 2,300 river miles (about 20 percent) of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater were impounded by the TVA by 1971 (TVA 1971). The subsequent completion of additional major impoundments on tributary streams (e.g., Duck River in 1976, Little Tennessee River in 1979) significantly increased the total miles impounded behind the 36 major dams in the Tennessee River system (Neves et al. 1997). Approximately 90 percent of the 562-mile length of the Cumberland River downstream of Cumberland Falls is either impounded (three locks and dams and the Wolf Creek Dam) or otherwise adversely impacted by cold-water discharges from the Wolf Creek Dam. Miller et al. (1984) located only two mussel specimens in a survey below the Wolf Creek Dam, which covered 68 miles of river that formerly harbored 39 species (Neel and Allen 1964). Other major U.S. Army Corps of Engineers (COE) impoundments on Cumberland River tributaries (e.g., Laurel River, Obey River, Caney Fork, Stones River) have inundated more than 125 miles of potential riverine habitat for the Cumberland elktoe, oyster mussel, and Cumberlandian combshell. Impoundments, as barriers to dispersal, contribute to the loss of local populations by blocking postextirpation recolonization (Luttrell et al. 1999). Population losses due to impoundments have probably contributed more to the decline of the Cumberlandian combshell, oyster mussel, and rough rabbitsfoot and most other Cumberlandian Region mussels than any other single factor (as the Cumberland elktoe and purple bean generally inhabit smaller rivers, impoundments have had less of an impact on them). Stream populations of these species thought to have been lost primarily or exclusively due to impoundments include the Cumberland River, Laurel River, Lynn Camp Creek, Rockcastle River, Beaver Creek, Obey River, Caney Fork, and Stones River in the Cumberland River system; and the South Fork Holston River, Holston River, Tennessee River, Little Tennessee River, Hiwassee River, Limestone Creek, Elk River, and Shoal Creek in the Tennessee River system. Reaches in other streams with extant populations of some of these species have also been destroyed by impoundments that invariably eliminated expanses of their occupied habitat (e.g., lower Big South Fork in the Cumberland River system; lower French Broad River, lower Little River [Tennessee], lower Clinch River, lower Powell River, lower Emory River, upper and lower Bear Creek, middle Duck River in the Tennessee River system). The majority of the extant populations of these species have been isolated due to impoundments (see “Patterns of Imperilment,” “Narrative Outline,” and Recovery Task 1.4.6 for a discussion of the consequences of population fragmentation), and some continue to decline and die off.

Stressor: Dredging and channelization
Exposure:
Response:
Consequence:
Narrative: Dredging and channelization activities have profoundly altered riverine habitats nationwide, with effects on streams summarized by Simons (1981), Bhowmik (1989), and Hubbard et al. (1993). DeHaan (1998) provided an annotated bibliography of sediment transport and deposition in large rivers. Hartfield (1993) and Neves et al. (1997) reviewed the specific effects of channelization on freshwater mollusks. Channelization impacts a stream’s physical (e.g., accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, riparian canopy loss) and biological (e.g., decreased fish and mussel diversity, changed species composition and abundance, decreased biomass and growth rates) characteristics (Stansbery and Stein 1971, Hartfield 1993, Hubbard et al. 1993). Since mussels need stable substrates to survive (Strayer 1999a), channel instability is probably the single most detrimental aspect of channelization (Hartfield 1993). Channel construction for navigation has been shown to increase flood heights (Belt 1975), thus exacerbating flood events that convey to streams large quantities of sediment with adsorbed contaminants. Channel maintenance may also result in downstream impacts (Stansbery 1970), such as increases in turbidity and sedimentation, which may smother benthic organisms. Impacts associated with barge traffic--the construction of fleeting areas, mooring cells, docking facilities, and propeller wash--also disrupt habitat. Although the volume of literature demonstrating the on-site and off-site environmental and economic consequences of dredging for navigation and flood control is substantial (Smith and Patrick 1991, Watters 2000), these activities continue in the Southeast. The entire length of the Tennessee River and much of the Cumberland River is maintained as a navigation channel with a series of locks and dams--nine on the Tennessee River and four on the Cumberland River. Although the dams themselves probably contributed more to the destruction of riverine habitat for mussels (including the oyster mussel and Cumberlandian combshell), channel maintenance activities continue to cause substrate instability and alteration in these rivers and may serve to diminish what habitat remains for the recovery of riverine species. Other streams, notably the lower Paint Rock River (Ahlstedt 1995-96) and portions of the Bear Creek system (McGregor and Garner, in press), have been channelized, primarily during ill-fated attempts to reduce flooding.

Stressor: Mineral extraction
Exposure:

Response:
Consequence:
Narrative: Heavy metal-rich drainage from coal mining and associated sedimentation have adversely impacted many stream reaches (Barnhisel and Massey 1969, Ahmad 1973, Curry and Fowler 1978), destroying mussel beds and preventing natural recolonization (Simmons and Reed 1973, McCann and Neves 1992). Neves et al. (1997) reviewed the effects of various mining activities on freshwater mollusks. The low pH commonly associated with mine runoff can lead to an inability of glochidia to clamp their valves on host tissues, thus preventing proper encystment (Huebner and Pynnönen 1992). Therefore, acid mine runoff may be having local impacts on the recruitment of, particularly, the Cumberland elktoe, since most of its range is within watersheds where coal mining is still occurring. In addition, interstitial spaces in streams, which is habitat critical for juvenile mussels, are clogged by sediment runoff from mines (Branson and Batch 1972). Circumstantial evidence indicates that salinity, a by-product of oil exploration activities, is lethal to some glochidia (Liquori and Insler 1985). Increased sedimentation and turbidity, reduction in pH from chemicals associated with acid mine drainage, and heavy metals have altered habitat in many streams to the point where mussels, including these species, are unable to reproduce, recruit, and survive these conditions. Impacts associated with coal mining activities have particularly altered upper Cumberland River system streams with diverse historical mussel faunas (Stansbery 1969, Blankenship 1971, Blankenship and Crockett 1972, Starnes and Starnes 1980, Schuster et al. 1989, Anderson et al. 1991) and have been implicated in the decline of Epioblasma species, especially in the Big South Fork (Neel and Allen 1964). Strip mining continues to threaten mussels in coal field drainages of the Cumberland Plateau (Anderson 1989, Warren et al. 1999) with increased sedimentation loads and acid mine drainage, including Cumberland elktoe and Cumberlandian combshell populations. The Marsh Creek population of the Cumberland elktoe has also been adversely affected and is still threatened by potential spills from oil exploration activities. Coal mining activities also occur in portions of the upper Powell and Clinch River systems, primarily in Virginia. Scores of active and inactive mines are known from these drainages (Hampson et al. 2000). Five mine tailings pond spills were reported from 1995 to 1999 in the upper Clinch and Powell River systems (Hampson et al. 2000), at least one of which resulted in a major fish kill (Koch, pers. comm., 1996). Research by Kitchel et al. (1981) indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981). Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. Known to be toxic to mussels and fishes, PAHs have been found at relatively high levels in the upper portions of the Clinch and Powell Rivers in Virginia (Hampson et al. 2000). In fact, Hampson et al. (2000) detected 29 different PAHs in stream sediment samples in the two watersheds. The Clinch River at Pendleton Island had concentrations of two measured PAHs, naphthalene and phenanthrene, at 400 micrograms per kilogram (µg/kg) and 570 µg/kg, respectively, both of which are above the protection guidelines for aquatic life. The Canadian probable-effect levels of 391 µg/kg and 515 µg/kg, respectively, have been established for these compounds. The probable-effect levels define concentrations above which adverse effects to aquatic organisms can be expected. Pendleton Island was once a stronghold for the rough rabbitsfoot and home to the oyster mussel, Cumberlandian combshell, and purple bean as well in the early 1980s (Ahlstedt 1991a). However, the fauna there was in marked decline less than a decade later. No live oyster mussels or Cumberlandian combshells were found in 1987 (Dennis 1989). Three other sites in the Clinch River system (i.e., lower Clinch River, Guest River, Copper Creek) had concentrations of these two compounds below the probable-effect levels. A site on the Powell River near Arthur, Tennessee,

had much higher levels of naphthalene and phenanthrene (1,600 µg/kg and 1,300 µg/kg, respectively) than at Pendleton Island. In the Emory River, downstream of a population of the purple bean in the Obed River, excessive naphthalene levels were detected (610 µg/kg). In a quantitative study in the Powell River, Ahlstedt and Tuberville (1997) attributed a 15-year decline of the oyster mussel, Cumberlandian combshell, and rough rabbitsfoot and the long-term decrease in species diversity (from 30 in 1979 to 21 in 1994) to general stream degradation due primarily to coal mining activities in the headwaters. Mining activities also likely contributed to the extirpation of the purple bean from the Powell River several decades ago. Iron and phosphate mining in the Duck River watershed was thought to have caused mussel declines in the early 1900s (Ortmann 1924a).

Stressor: Gravel mining
Exposure:
Response:
Consequence:
Narrative: In-stream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, Yokley and Gooch 1976, Grace and Buchanan 1981, Hartfield and Ebert 1986, Schuster et al. 1989, Hartfield 1993, Howard 1997). Lagasse et al. (1980), Kanehl and Lyons (1992), and Roell (1999) reviewed the physical and biological effects of mining sediment from streams. Negative impacts include riparian forest clearing (e.g., mine site establishment, access roads, lowered floodplain water table); stream channel modifications (e.g., geomorphic instability, altered habitat, disrupted flow patterns [including lowered elevation of stream flow], sediment transport); water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature); macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation); and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions) (see discussion in “Sedimentation”). Once mussels have been eliminated, a decade or more may pass before recolonization occurs (Stansbery 1970, Grace and Buchanan 1981). Substrate disturbance and sedimentation impacts can also be realized for considerable distances downstream (Stansbery 1970), and possibly upstream (Hartfield 1993). Gravel mining activities threaten the Cumberlandian combshell populations in the Powell River and in Buck Creek, the latter stream representing one of only two remaining populations of this species in the entire Cumberland River system. Mining activities on the Elk River (Ahlstedt 1991b) may have played a role in the extirpation of the oyster mussel and Cumberlandian combshell from that river. Gravel removal was apparent at 12 sites along a 40-mile stretch of the lower Elk River during 1999 mussel sampling(Anonymous 1999). Activities that occur without a permit, unless controlled, may prevent the long-term reintroduction of some of the 13 federally listed mussels that are known from the Elk.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Contaminants contained in point and nonpoint discharges can degrade water and substrate quality and adversely impact, if not destroy, mussel populations (Horne and McIntosh 1979, Neves and Zale 1982, McCann and Neves 1992, Havlik and Marking 1987). Although chemical spills and other point sources (e.g., ditch, swale, artificial channel, drainage pipe) of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result, in part, from the subtle, pervasive effects of chronic low-level contamination

(Naimo 1995). The effects of excessive concentrations of heavy metals and other contaminants on freshwater mussels were studied by Mellinger (1972), Fuller (1974), Havlik and Marking (1987), Naimo (1995), Keller and Lydy (1997), and Neves et al. (1997). Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also negatively affect biological processes (Jacobson et al. 1993, Naimo 1995, Keller and Zam 1991, Keller and Lydy 1997). In laboratory experiments, mussels suffered mortality when exposed to 2.0 parts per million (ppm) cadmium, 12.4 ppm chromium, 19.0 ppm copper, and 66.0 ppm zinc (Mellinger 1972, Havlik and Marking 1987). Most metals are persistent in the environment (Miettinen 1977), remaining available for uptake, transportation, and transformation by organisms for long periods (Hoover 1978). Highly acidic pollutants such as metals are capable of contributing to mortality by dissolving mussel shells (Stansbery 1995). Among other pollutants, ammonia has been shown to be lethal to mussels at concentrations of 5.0 ppm (Havlik and Marking 1987). Ammonia is oftentimes associated with animal feedlots, nitrogenous fertilizers, and the effluents of older municipal wastewater treatment plants (Goudreau et al. 1993). This contaminant may become more problematic for juvenile mussels during periods of low flow, when water temperatures increase (Newton et al. 2003b). In stream systems, ammonia is most prevalent at the substrate/water interface (Frazier et al. 1996). Due to its high level of toxicity and the fact that the highest concentrations occur in the microhabitat, where mussels live, ammonia should be considered among the factors potentially limiting the survival and recovery of mussels at some locations (Augspurger et al., in press). Certain adult species may tolerate short-term exposure (Keller 1993). However, the effects of heavy metals and other toxicants are especially profound on juvenile mussels (Robison et al. 1996) and on the glochidia, which appear to be very sensitive to toxicants such as ammonia (Goudreau et al. 1993). Low levels of some metals may inhibit glochidial attachment (Huebner and Pynnönen 1992). Juvenile mussels may inadvertently ingest contaminated silt particles while feeding (see “Food Habits”). Mussel recruitment may therefore be reduced in habitats with low but chronic heavy metal and other toxicant inputs (Yeager et al. 1994, Naimo 1995, Ahlstedt and Tuberville 1997), which may have contributed to the demise of these five species. Common contaminants associated with households and urban areas, particularly those from industrial and municipal effluents, may include heavy metals, ammonia, chlorine, phosphorus, and numerous organic compounds. Nonpoint-source runoff from urban areas tends to have the highest levels of many pollutants, such as phosphorus and ammonia, when compared to other catchments (Mueller et al. 1995). Wastewater is discharged at sites throughout the country with permits (and some without permits) issued by the National Pollution Discharge Elimination System (NPDES). Elimination sites are ubiquitous in watersheds containing rough rabbitsfoot populations, providing ample opportunities for some pollutants to enter streams. Collectively, pollutants from these sources may cause decreased dissolved oxygen levels, increased acidity, and other water chemistry changes that may be lethal to mussels (Horne and McIntosh 1979, Rand and Petrocelli 1985, Sheehan et al. 1989, Keller and Zam 1991, Dimock and Wright 1993, Goudreau et al. 1993, Jacobson et al. 1993, Keller 1993). Sediment from the upper Clinch River, where several of these species occur, was found to be toxic to juvenile mussels (Robison et al. 1996). Ahlstedt and Tuberville (1997) speculated that the presence of toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream. Wilcove and Bean (1994) reported that studies indicated that mussel reproduction below the site of the Appalachian Power Company’s (APCO) electric generating station in Carbo, Virginia, was being inhibited by copper discharges. In addition, copper was shown to be toxic to mussels at levels below the U.S. Environmental Protection Agency (EPA) criteria established in Virginia. The Virginia State Water Control Board began proceedings to impose a special water quality standard for copper below the plant. In 1992, the State and APCO agreed on a lower standard for copper for this specific stretch of the Clinch. APCO is spending several million dollars to control copper discharge from its facility to meet the new standard (Wilcove and Bean 1994). Although the Clean Water Act (CWA), administered by the EPA, has helped eliminate many point-source effluents, “straight pipes” (pipelines conveying untreated household effluents; e.g., chlorine, detergents, household chemicals, human waste, etc., from rural homes directly into streams) continue to discharge wastes. Fraley and Ahlstedt (2000) thought that effluents from straight pipes were partially to blame for the documented decline of the native mussel fauna in Copper Creek from 19 species in 1980 to 11 species in 1998. Included in the historical Copper Creek fauna were the oyster mussel, rough rabbitsfoot, and purple bean, although only the latter species was found live in 1998. Numerous other streams in the Cumberlandian Region doubtless also have straight pipes discharging pollutants into mussel habitat. Agricultural sources of chemical contaminants are considerable and include two broad categories--nutrients and pesticides (Frick et al. 1998). Nutrient enrichment generally occurs as a result of runoff from livestock farms and feedlots and from fertilizers used on row crops. Various OWCs may also be associated with livestock concentrations (Kolpin et al. 2002). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated, resulting in overenrichment, a condition exacerbated by low-flow conditions. Excessive stands of filamentous algae, a common manifestation of overenrichment, alter the surface of the stream bottom and may represent a shift in algal communities that could disrupt, particularly, juvenile mussel food supplies. Juvenile mussels, utilizing interstitial habitats, are particularly affected by excessive levels of algae-consuming dissolved oxygen during nocturnal respiration (Sparks and Strayer 1998). Increased risks from bacterial and protozoan infections to eggs and glochidia may also pose a threat (Fuller 1974). Hoos et al. (2000) summarized data on nutrient loading in the lower Tennessee River system, where overenrichment was the cause of impairment in 37 stream segments. Nonpoint sources, primarily agricultural inputs, accounted for the largest percentage of total nitrogen and total phosphorus in all streams tested in the study area. Relatively high levels of nutrients were prevalent in the Duck River, where a large population of the oyster mussel occurs. Nutrient levels were also analyzed in the upper Tennessee River system by Hampson et al. (2000). Overall, nutrient concentrations were generally lower than national concentrations and were relatively high only on a localized scale. Secondly, pesticides, primarily from row c

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Sedimentation is widely thought to have contributed to the decline of mussel populations (Kunz 1898; Ellis 1931, 1936; Cordone and Kelly 1961; Imlay 1972; Coon et al. 1977; Marking and Bills 1979; Wilber 1983; Dennis 1985; Schuster et al. 1989; Wolcott and Neves 1990; Houp 1993; Richter et al. 1997, Brim Box 1999; Henley et al. 2000; Fraley and Ahlstedt 2000). Specific biological impacts on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity, and physical smothering (Ellis 1936, Stansbery 1971, Markings and Bills 1979, Kat 1982, Vannote and Minshall 1982, Aldridge et al.

1987, Waters 1995). Brim Box (1999) showed that burying adult mussels under 5.5 inches of sediment in the Apalachicola, Chattahoochee, and Flint River basin significantly decreased their chances of surviving. Intuitively, much thinner layers of sediment may result in juvenile mortality. Some studies tend to indicate that the primary impacts of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999). The physical effects of sediment on mussels appear to be multifold (Brim Box and Mossa 1999). They are potentially impacted by changes in suspended and bed material load; bed sediment composition associated with increased sediment production and runoff in the watershed; channel changes in form, position, and degree of stability; changes in depth or the width/depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave them high and dry (Vannote and Minshall 1982, Kanehl and Lyons 1992, Hartfield 1993, Brim Box and Mossa 1999. Interstitial spaces in mixed substrates may become clogged with sediment (Gordon et al. 1992). When clogged, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999), thus reducing habitat for juvenile mussels and some adults as well. Salomons et al. (1987) and the National Research Council (1992) indicated that sediment may act as a vector for delivering contaminants such as nutrients and pesticides to streams. Juveniles can readily ingest contaminants adsorbed to silt particles during normal feeding activities (see “Food Habits”). These factors may help explain, in part, why so many mussel populations appear to be experiencing recruitment failure. Host fish/mussel interactions may be indirectly impacted by changes in stream sediment regimes through three mechanisms (Brim Box and Mossa 1999). First, fish abundance (Berkman and Rabeni 1987), diversity (Waters 1995), and reproduction (Muncy et al. 1979) may be reduced with increased sedimentation. Second, excessive sedimentation likely impedes host fish attractant mechanisms (e.g., mantle flaps, conglutinates, superconglutinates that mimic fish prey items; (Haag et al. 1995, Burkhead et al. 1997). Third, sedimentation on shoal substrates may interfere with the ability of some species’ adhesive conglutinates to adhere to rock particles (Hartfield and Hartfield 1996). Many Southeastern streams have increased turbidity levels due to siltation (van der Schalie 1938). Some of these five species attract host fishes with visual cues, luring fish into perceiving that their glochidia are prey items. Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991) and may have contributed to population declines in some of these mussel species. In addition, mussels may be indirectly affected when turbidity levels significantly reduce the amount of light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992). Agricultural activities produce the most significant amount of sediment that enters streams (Waters 1995). Neves et al. (1997) stated that agriculture (including both sediment and chemical runoff) affects 72 percent of the impaired river miles in the country. Unfortunately, the CWA does not regulate agricultural runoff, return waters, or discharge flows (D. Powell, EPA, letter dated June 20, 2003). Armour et al. (1991) reviewed the effects of livestock grazing on riparian and stream ecosystems. Unrestricted access by livestock is a significant threat to streams (Trimble and Mendel 1995) and their mussel populations throughout much of the Cumberlandian Region (Anonymous 1999, Fraley and Ahlstedt 2000). Grazing may reduce infiltration rates and increase runoff and erosion (Brim Box and Mossa 1999). Trampling causes or accelerates stream-bank erosion, and grazing reduces a bank’s resistance to erosion (Armour et al. 1991, Trimble and Mendel 1995). In addition, livestock may add nutrients to streams at levels that are not easily assimilated, particularly during low-flow conditions, resulting in overenrichment. Fraley and Ahlstedt (2000) attributed the decline of the Copper Creek mussel fauna between 1980 and 1998, among other factors, to an increase in cattle grazing and loss of riparian vegetation in the stream. They considered the oyster mussel and rough rabbitsfoot as possibly being extirpated from Copper Creek. Erosion from silvicultural activities accounts for 6 percent of the nation's sediment pollution (Henley et al. 2000). Sedimentation impacts are more the result of logging roads than the actual harvesting of timber (Waters 1995, Brim Box and Mossa 1999).

Stressor: Developmental activities
Exposure:
Response:
Consequence:
Narrative: Developmental activities associated with urbanization (e.g., highways, building construction, infrastructure creation, recreational facilities) may contribute significant amounts of sediment and other pollutants in quantities that may be detrimental to stream habitats (Waters 1995, Couch and Hamilton 2002). Urban development changes sediment regimes by creating impervious surfaces and drainage system installations (Brim Box and Mossa 1999). The highest erosion rates are generally associated withconstruction activities, which can contribute sediment at a rate 300 times greater than from forested land (USDA 1977). Stream channel erosion contributes up to two-thirds of the total sediment yield in urbanized watersheds (Trimble 1997). With development, watersheds become more impervious, resulting in increased storm-water runoff into streams (Myers-Kinzie et al. 2002) and a doubling in annual flow rates in completely urbanized streams (DeWalle et al. 2000). Impervious surfaces may reduce sediment input into streams but result in channel instability by accelerating storm-water runoff, which increases bank erosion and bed scouring (Brim Box and Mossa 1999). Stream channels become highly unstable as they respond to increased flows by incising, which increases shear stress and bed mobilization (Doyle et al. 2000). With increasing shear stress, benthic organisms become increasingly dislodged downstream (Myers-Kinzie et al. 2002). Studies have indicated that high shear stress is associated with low mussel densities (Layzer and Madison 1995) and that peak flows and substrate movement limits mussel communities, particularly at the juvenile stage (Myers-Kinzie et al. 2002). For some of these species, a considerable amount of habitat has been lost, particularly in metropolitan areas in Tennessee (e.g., Knoxville, Nashville, Chattanooga). Streams that contain these five species, and which are currently threatened with development activities, include Sinking Creek (potential interstate highway, industrial park; Cumberland elktoe) and Buck Creek (potential interstate highway, Cumberlandian combshell), Kentucky; Bear Creek, (instream gold mining, Cumberlandian combshell), Alabama and Mississippi; and the Duck River (general development from rapid growth, oyster mussel) Tennessee (Butler, pers. obs., 2002; Cicerello, pers. comm., 2003; L. Colley, TNC, pers. comm., 2002). Water withdrawals for agricultural irrigation and municipal and industrial water supplies are an increasing concern for all aquatic resources and are directly correlated with expanding human populations. This impact has the potential to be a particular problem for the Cumberland elktoe population in the Big South Fork system and the oyster mussel population in the Duck River. Droughts may also be a threat to these species, particularly populations occurring in smaller streams. Impacts include decreased flow velocities and depressed dissolved oxygen levels (Johnson et al. 2001). Stochastic events, such as droughts, may be exacerbated by global warming and water withdrawals. These anthropogenic activities act insidiously to lower water tables, thus making mussel populations susceptible to depressed stream levels.

Stressor: Predation
Exposure:

Response:
Consequence:
Narrative: Muskrat predation is one factor limiting the Cumberland elktoe.

Stressor: Invasives
Exposure:
Response:
Consequence:
Narrative: They asian clam has been implicated as a competitor with native mussels for resources such as food, nutrients, and space (Heard 1977, Kraemer 1979, Clarke 1986), particularly as juveniles (Neves and Widlak 1987). According to Strayer (1999b), dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles. Periodic dieoffs may produce enough ammonia and consume enough oxygen to kill native mussels (Strayer 1999b). The invasion of the nonnative zebra mussel (Dreissena polymorpha [Pallas, 1773]) poses a threat to the mussel fauna of the Cumberlandian Region (Ricciardi et al. 1998). Zebra mussels in the Great Lakes have attached, in large numbers (up to 10,000 per unionid), to the shells of live and fresh dead native mussels (Schlosser and Kovalak 1991), and they have been implicated in the loss of mussel beds (Hunter and Bailey 1992, Masteller et al. 1993, Schlosser and Nalepa 1995). Although zebra mussels are now in the Tennessee and Cumberland River systems, the extent to which they will impact native mussels is unknown.

Recovery

Reclassification Criteria:
Downlisting from endangered to threatened status will occur when the following criteria are met for the protection of extant stream populations, discovery of currently unknown stream populations, and/or reestablishment of historical stream populations: (1) six streams with distinct viable populations of the Cumberlandian combshell; (2) one distinct naturally reproduced year class exists within each of the viable populations; (3) research studies of the mussels' biological and ecological requirements have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring; (4) no foreseeable threats exist that would likely impact the survival of the species over a significant portion of their ranges; (5) within larger streams the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable; and (6) biennial monitoring of the five species yields the results outlined in criterion (1) above over a 10-year period.

Delisting Criteria:
Delisting will occur when the following criteria are met for protecting extant stream populations and reestablishing viable stream populations: (1) nine streams with distinct viable populations of the oyster mussel, nine streams with distinct viable populations of the Cumberlandian combshell have been established; (2) two distinct naturally reproduced year classes exist within each of the viable populations; (3) research studies pertaining to the mussels' biological and ecological requirements have been completed and recovery measures developed and

implemented from these studies have been successful as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited in each of the viable populations as determined through biennial monitoring; (4) no foreseeable threats exist that would likely threaten the survival of any of the viable populations; (5) within larger streams the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable; and (6) biennial monitoring of the five species yields the results outlined in criterion (1) above over a 10-year period.

Recovery Actions:

- Continue to refine propagation technology.
- Augment and expand the range of extant populations to ensure their viability.
- Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality.
- Determine the degree of threat that increased coal mining, and oil and gas drilling may have on this species.
- Protect habitat through acquisitions and easements.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Continue efforts to augment and expand the range of extant populations to ensure their viability. For example, CRMRC (2010) recommended the following Cumberlandian Region streams as potential reintroduction sites: Tennessee River system – Bear Creek, Alabama/Mississippi; Duck River, Tennessee. • Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality. For example, CRMRC (2010) recommended the following Cumberlandian Region streams as potential augmentation or reintroduction sites: 	 Tennessee River system – Tennessee River tributary tailwaters, Alabama and Tennessee: Elk River, Alabama; Nolichucky River, Tennessee; Paint Rock River, Alabama; Limestone Creek, Alabama; Copper Creek, Virginia; upper French Broad River, Tennessee; lower Pigeon River, Tennessee; Hiwassee River, Tennessee; Tennessee River mainstem tailwaters (Lake Guntersville), Alabama; Wilson Creek, Alabama; upper Holston River, Tennessee. 	 Cumberland River system – Rockcastle River, Kentucky; Middle Fork Rockcastle River, Kentucky; and Red River, Kentucky/Tennessee. • Continue investigations into the cause of long-term mussel declines in the Virginia portion of the Clinch River (Zone of Decline), as well as more recent acute declines (die-offs) in downstream portions of the Clinch River in Tennessee. • Protect habitat through acquisitions and easements with federal, state, and private partners. • Continue to educate the public about water quality and freshwater mussels. • Continue quantitative and qualitative efforts to monitor existing populations, including long-term monitoring efforts. The Service and its partners should use demographic and genetic monitoring to monitor populations over time. (USFWS, 2019)

References

Final rule for critical habitat

Recovery Plan

Nature Serve

U.S. Fish and Wildlife. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered Mussels in the Tennessee and Cumberland River Basins. Final rule. 69 FR 53136 - 53180 (August 31, 2004).

Recovery Plan, Nature Serve, Five year review

Recovery Plan, Nature Serve, Five year review. USFWS. 2019. Cumberlandian Combshell [Epioblasma brevidens (Lea, 1861)] 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 31 pp.

Recovery Plan and five year review

USFWS. 2019. Cumberlandian Combshell [Epioblasma brevidens (Lea, 1861)] 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 31 pp.

SPECIES ACCOUNT: *Epioblasma capsaeformis* (Oyster mussel)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The oyster mussel has a periostracum that is dull to sub-shiny yellowish to green in color, with numerous narrow dark green rays. The shells of females are expanded along the posterior ventral margin and quite thin and fragile toward the shell's posterior margin. The nacre is whitish to bluish white in color.

Taxonomy

The pronounced development of the posterior-ventral region in females distinguishes Epioblasma from similarly shaped species. The Oyster mussel population from the Duck River in Tennessee ahs been proposed as a separate species from the Oyster mussel populations in the upper Tennessee Watershed. The proposed taxonomic changes would reduce the Oyster mussel to 2 extant locations in the upper Tennessee Watershed. The new species in the Duck River would have only one known extant location.

Historical Range

The oyster mussel was historically one of the most widely distributed Cumberlandian mussel species. Its range historically included four physiographic provinces (Interior Low Plateau, Cumberland Plateau, Ridge and Valley, and Blue Ridge) and six states (Alabama, Georgia, Kentucky, North Carolina, Tennessee, and Virginia). In the Cumberland River, it occurred from the base of Cumberland Falls, McCreary and Whitely Counties, Kentucky, downstream to Stewart County, Tennessee. In the Tennessee River, it occured throughout the main stem, downstream to Colbert and Lauderdale Counties, Alabama. Dozens of tributaries in the Cumberland and Tennessee River Systems also harbored this species historically.

Current Range

The oyster mussel is now considered extirpated form the entire Cumberland River system. Oyster mussels have also been eliminated from the entire Tennessee River main stem and numberous tributaries. The remaining extant populations occur in the Clinch River in Scott County, Virginia, and Hancock County, Tennessee; Nolichucky River in Cocke and Hamblen Counties, Tennessee; and the Duck River in Marshall County, Tennessee. The Duck River population has been determined to be a separate species. This would result in only two extant populations of the true oyster mussel.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 8/31/2004.

Legal Description

On August 31, 2004, the U.S. Fish and Wildlife Service designated critical habitat for the endangered oyster mussel (Epioblasma capsaeformis) under the Endangered Species Act of

1973, as amended (69 FR 53136 - 53180).

Critical Habitat Designation

Critical habitat for the oyster mussel (Epioblasma capsaeformis) is designated in Units 1, 2, 4, 5, 6, 9, and 10; in AL, KY, MS, TN, and VA.

Unit 1. Duck River, Maury and Marshall Counties, Tennessee. Unit 1 encompasses 74 rkm (46 rmi) of the main stem of the Duck River channel from rkm 214 (rmi 133) (0.3 rkm (0.2 rmi) upstream of the First Street Bridge in the City of Columbia, Maury County, Tennessee, upstream to Lillard Mill Dam at rkm 288 (rmi 179), Marshall County, Tennessee. This reach of the Duck River contains a robust, viable population of the oyster mussel (Ahlstedt 1991b; Gordon 1991; S.A. Ahlstedt, pers. comm. 2002) and historically supported the Cumberlandian combshell (Hinkley and Marsh 1885; Ortmann 1925; Isom and Yokley 1968; van der Schalie 1973; Gordon 1991). Approximately 59 percent of this Unit is now bounded by the YWMA (recently transferred from the TVA to TWRA).

Unit 2. Bear Creek, Colbert County, Alabama, and Tishomingo County, Mississippi. Unit 2 encompasses 40 rkm (25 rmi) of the main stem of Bear Creek from the backwaters of Pickwick Lake at rkm 37 (rmi 23), Colbert County, Alabama, upstream through Tishomingo County, Mississippi, ending at the Mississippi/ Alabama State line. Recent mussel surveys in the Mississippi section of Bear Creek confirmed that the Cumberlandian combshell is still extant (R.M. Jones, pers. comm. 2002), and continues to be present in the Colbert County, Alabama portion of the unit (Isom and Yokley 1968; McGregor and Garner 2004). Bear Creek is in the historical range of the oyster mussel (Ortmann 1925).

Unit 4. Powell River, Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia. Unit 4 encompasses 154 rkm (94 rmi) and includes the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. This reach is currently occupied by the Cumberlandian combshell (Ahlstedt 1991b; Gordon 1991) and rough rabbitsfoot (Service 2004), and was historically occupied by the oyster mussel (Wolcott and Neves 1990) and the purple bean (Ortmann 1918). It is also existing critical habitat for the federally listed slender chub and yellowfin madtom.

Unit 5. Clinch River and tributaries, Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia. Unit 5 totals 272 rkm (171 rmi), including 242 rkm (148 rmi) of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia; 4 rkm (2.5 rmi) of Indian Creek from its confluence with the Clinch River upstream to the fourth Norfolk Southern Railroad crossing at Van Dyke, Tazewell County, Virginia; and 21 rkm (13 rmi) of Copper Creek from its confluence with the Clinch River upstream to Virginia State Route 72, Scott County, Virginia. The Clinch River main stem currently contains the oyster mussel, rough rabbitsfoot, Cumberlandian combshell, and purple bean (Gordon 1991; Ahlstedt and Tuberville 1997; S.A. Ahlstedt, pers. comm. 2002). Indian Creek currently supports populations of the purple bean and rough rabbitsfoot (Winston and Neves 1997; Watson and Neves 1996). Copper Creek is currently occupied by a low-density population of the purple bean and contains historical records of both the oyster mussel and rough rabbitsfoot (Ahlstedt 1981; Fraley and Ahlstedt 2001; S.A. Ahlstedt, pers. comm. 2003). Copper Creek is critical habitat for the yellowfin madtom and a portion of the Clinch River main stem section is critical habitat for both the slender chub and the yellowfin madtom.

Unit 6. Nolichucky River, Hamblen and Cocke Counties, Tennessee. Unit 6 includes 8 rkm (5 rmi) of the main stem of the Nolichucky River and extends from rkm 14 (rmi 9) (approximately 0.6 rkm (0.4 rmi) upstream of Enka Dam to Susong Bridge in Hamblen and Cocke counties, Tennessee. The Nolichucky River currently supports a small population of the oyster mussel (S.A. Ahlstedt, pers. comm. 2002) and was historically occupied by the Cumberlandian combshell (Gordon 1991).

Unit 9. Big South Fork and Tributaries, Fentress, Morgan, and Scott Counties, Tennessee, and McCreary County, Kentucky. Unit 9 encompasses 153 rkm (95 rmi) and consists of 43 rkm (27 rmi) of the Big South Fork of the Cumberland River main stem from its confluence with Laurel Crossing Branch downstream of Big Shoals, McCreary County, Kentucky, upstream to its confluence with the New River and Clear Fork, Scott County, Tennessee; 11 rkm (7 rmi) of North White Oak Creek from its confluence with the Big South Fork upstream to Panther Branch, Fentress County, Tennessee; 14.5 rkm (9.0 rmi) of the New River from its confluence with Clear Fork upstream to U.S. Highway 27, Scott County, Tennessee; 40 rkm (25 rmi) of Clear Fork from its confluence with the New River upstream to its confluence with North Prong Clear Fork, Morgan and Fentress Counties, Tennessee; 10 rkm (6 rmi) of White Oak Creek from its confluence with Clear Fork upstream to its confluence with Bone Camp Creek, Morgan County, Tennessee; 6 rkm (4 rmi) of Bone Camp Creek from its confluence with White Oak Creek upstream to Massengale Branch, Morgan County, Tennessee; 14.5 rkm (9.0 rmi) of Crooked Creek from its confluence with Clear Fork upstream to Buttermilk Branch, Fentress County, Tennessee; and 14.5 rkm (9 rmi) of North Prong Clear Fork from its confluence with Clear Fork upstream to Shoal Creek, Fentress County, Tennessee. The main stem of the Big South Fork currently supports the Cumberland elktoe and the best remaining Cumberlandian combshell population in the Cumberland River System (Bakaletz 1991; Gordon 1991; R.R. Cicerello, pers. comm. 2003). The main stem of the Big South Fork historically contained the oyster mussel (S.A. Ahlstedt, pers. comm. 2002; Service 2004). The Epioblasma mussel that currently inhabits the Big South Fork main stem, and that is occasionally referred to as the oyster mussel, is now recognized as a sister species of the tan riffleshell (see ''Taxonomy, Life History, and Distribution'' section) (Service 2004; J. Jones, pers. comm. 2003). The remainder of the unit contains habitat currently occupied by the Cumberland elktoe (Call and Parmalee 1981; Bakaletz 1991; Gordon 1991). The largest population of Cumberland elktoe in Tennessee is in the headwaters of the Clear Fork System (Call and Parmalee 1981; Bakaletz 1991). The Big South Fork and its many tributaries may actually serve as habitat for one large interbreeding population of the Cumberland elktoe (Service 2004).

Unit 10. Buck Creek, Pulaski County, Kentucky. Unit 10 encompasses 58 rkm (36 rmi) and includes Buck Creek from the State Route 192 Bridge upstream to the State Route 328 Bridge in Pulaski County, Kentucky. Buck Creek is currently occupied by the Cumberlandian combshell (Gordon 1991; Hagman 2000; R.R. Cicerello, pers. comm. 2003) and historically supported the oyster mussel (Schuster et al. 1989; Gordon 1991). This unit is adjacent to the DBNF.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the oyster mussel (Epioblasma capsaeformis) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the five mussels and their host fish;

(ii) Geomorphically stable stream and river channels and banks;

(iii) Stable substrates consisting of mud, sand, gravel, and/or cobble/ boulder, with low amounts of fine sediments or attached filamentous algae;

(iv) Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and

(v) Fish hosts with adequate living, foraging, and spawning areas for them.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, or presence of fish hosts. All of these units are threatened by actions that alter the stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); and point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation. Habitat fragmentation, population isolation, and small population size compounds these threats to the species. Various activities in or adjacent to each of the critical habitat units may affect one or more of the primary constituent elements that are found in the unit.

Life History

Feeding Narrative

Larvae: Glochidia rely on a host (wounded darter (Etheostoma vulneratum), redline darter (E. rufilineatum), bluebreast darter (E. Camarum), dusky darter (Percina sciera), banded sculpin (Cottus carolinae), black sculpin (C. Baileyi), and mottled sculpin (C. baidi), greenside darter (E. blennioides), fantail darter (E. flabellare))

Juvenile: Juvenile mussels employ foot (pedal) feeding and are thus suspension/deposit feeders (Yeager et al. 1994). The juvenile diet (up to 2 weeks of age) includes bacteria, algae (i.e., nonfilamentous, non-blue green), and diatoms, with some detrital and inorganic colloidal particles (Yeager et al. 1994).

Adult: Adult freshwater mussels are filter feeders, orienting themselves in the substrate to facilitate the siphoning of the water column for oxygen and food (Kraemer 1979). Specific food habits of the oyster mussel is unknown, but they likely ingest food items similar to those consumed by other riverine mussels. Mussels are known to consume bacteria, detritus, assimilated organic material, diatoms, phytoplankton, zooplankton, phagotrophic protozoans, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Ukeles 1971, Fuller

1974, Baldwin and Newell 1991, Neves et al. 1996).

Reproduction Narrative

Adult: Spawning occurs in the lampsiline oyster mussel in late summer and early fall, with glochidia being overwintered for release in the spring (Jones, letter dated June 9, 2003). In the Powell River, Yeager and Saylor (1995) found 58 percent of the females gravid in May (water temperature from 59.0° to 64.0°F). The age of gravid females, using the qualitative external growth ring method (Chamberlain 1931, Crowley 1957), was estimated at 7 to 10 years but may be as young as 4 to 5 years (Jones, pers. comm., 2002). Gravid females move to the surface of the substrate in April and May, where they open their valves wide, exposing sky blue to bluish white mantle pads (Ahlstedt, pers. comm., 2001). Attached to the posterior region of the mantle pad are two tiny fingerlike projections that resemble the cercae (tail) of insect larvae (e.g., stoneflies, mayflies); they rotate in a circular motion and serve as microlures for their host fishes (Jones, pers. comm., 2003). Tiny teethlike projections on the marsupial expansion of the valves are thought to temporarily grasp a host fish while it is investigating the microlures as possible prey items, while the female expels her glochidia into its buccal (throat) cavity. Approximately 12,000 to 16,000 glochidia per female have been observed (Neves, pers. comm., 2000). Seven native fish species have been identified as hosts--the wounded darter (Etheostoma vulneratum), redline darter (E. rufilineatum), bluebreast darter (E. camarum), dusky darter (Percina sciera), banded sculpin (Cottus carolinae), black sculpin (C. baileyi), and mottled sculpin (C. bairdi) (Yeager and Saylor 1995; Jones and Neves, USGS, unpub. data). Transformation took from 19 to 34 days, at 60.4° to 62.4°F (Yeager and Saylor 1995).

Geographic or Habitat Restraints or Barriers

Larvae: impoundments

Juvenile: impoundments

Adult: impoundments

Spatial Arrangements of the Population

Larvae: clumped according to suitable resources

Juvenile: clumped according to suitable resources

Adult: clumped according to suitable resources

Environmental Specificity

Larvae: specialist; requires a host

Juvenile: generalist

Adult: generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensititve to water quality impairments

Juvenile: likely low; sensititve to water quality impairments

Adult: likely low; sensititve to water quality impairments

Site Fidelity

Larvae: dependent on host

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Adult mussels are ideally found in localized patches (beds) in streams, almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Vannote and Minshall 1982, Neves and Widlak 1987, Leff et al. 1990, Strayer 1997). Physical qualities of the sediment (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediment, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999). Water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams (Huehner 1987). The oyster mussel inhabits small to medium-sized rivers (Dennis 1985), and sometimes large rivers, in areas with coarse sand to boulder substrate (rarely in mud) and moderate to swift currents (Gordon 1991). It is sometimes found associated with water-willow (Justicia americana) beds (Ortmann 1924a, Gordon and Layzer 1989) and in pockets of gravel between bedrock ledges in areas of swift current (Neves 1991). Gordon (1991) reports that this species, like other freshwater mussels, can bury itself below the substrate surface, but females have been observed to lie on top of the substrate while displaying and releasing glochidia.

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Dependent on host

Juvenile: Non-migratory

Adult: Non-migratory

Dispersal

Larvae: dependent on host

Juvenile: Limited; passive movement via flushing event

Adult: Limited; passive movement via flushing event

Dependency on Other Individuals or Species for Dispersal

Larvae: yes; host

Dispersal/Migration Narrative

Larvae: Primary dispersal of the Cumberland Elktoe is likely via through host.

Juvenile: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Adult: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Population Information and Trends

Population Trends:

Some populations are increasing while others seem to be decreasing

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

1 to 20

Population Size:

unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

The oyster mussel population in the lower Clinch River appears to have increased dramatically in recent years with conservative estimates at 250, 000+ individuals based on 2004 and 2005 quadrat data from VPI. The Nolichucky River population in small and of doubtful viability. The Duck River population appears to be doing well in the lower portion of this river. Wilson Dam tailwater NEP popuation is decreasing due to predation.

Threats and Stressors

Stressor: Non-point source pollution
Exposure:
Response:
Consequence:
Narrative: Non-point source pollution from land surface runoff can originate from virtually any land use activity (e.g., coal mining and agricultural activities) and may be correlated with impervious surfaces and storm water runoff from urban areas. Pollutants entering the Nolichucky, Clinch, and Duck Rivers may include sediment, fertilizers, herbicides, pesticides, animal wastes, pharmaceuticals, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streamssuch that the habitat and food sources for species like the oyster mussel are negatively impacted.

Stressor: Coal mining
Exposure:
Response:
Consequence:
Narrative: Coal mining activity has increased in the Clinch River watershed in recent years, and coal fines in the upper river, Virginia, are moving downstream into Tennessee. A 585-megawatt coal powered electric generation facility is expected to be constructed along the Clinch River in Virginia City, Wise County, Virginia. Effluent discharge, run-off from fly ash storage, and other sources related to the operation of the facility represent new threats, and may result in further impacts to the oyster mussel populations in Tennessee.

Stressor: Energy exploration/development
Exposure:
Response:
Consequence:
Narrative: Oil, gas, and coal exploration and development are on the increase in the upper Clinch River watershed and the New River watershed. The largest oyster mussel populations occur in the lower Clinch River and coal fines are already being found in increasing amounts in these populations. The New River is a major tributary to the Big South Fork that influences the quality of the oyster mussel habitat. The potential negative impacts to mussels and their habitat will have to be monitored closely as exploration and development increase.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The oyster mussel and its habitats are afforded limited protection from water quality degradation under the Clean Water Act and the Tennessee Water Quality Control Act. However, these laws focus on point-source discharges, and many water quality problems are the result of non-point source discharges. Therefore, these laws and corresponding regulations have been inadequate to halt population declines and degradation of habitat for the oyster mussel.

Recovery

Reclassification Criteria:
Downlisting from endangered to threatened status will occur when the following criteria are met for the protection of extant stream populations, discovery of currently unknown stream populations, and/or reestablishment of historical stream populations: (1) six streams with distinct viable populations of the oyster mussel; (2) one distinct naturally reproduced year class exists within each of the viable populations; (3) research studies of the mussels' biological and ecological requirements have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring; (4) no foreseeable threats exist that would likely impact the survival of the species over a significant portion of their ranges; (5) within larger streams the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable; and (6) biennial monitoring of the species yields the results outlined in criterion (1) above over a 10-year period.

Delisting Criteria:
Delisting will occur when the following criteria are met for protecting extant stream populations and reestablishing viable stream populations: (1) nine streams with distinct viable populations of the oyster mussel; (2) two distinct naturally reproduced year classes exist within each of the viable populations; (3) research studies pertaining to the mussels' biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited in each of the viable populations as determined through biennial monitoring; (4) no foreseeable threats exist that would likely threaten the survival of any of the viable populations; (5) within larger streams the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable; and (6) biennial monitoring of the five species yields the results outlined in criterion (1) above over a 10-year period.

Recovery Actions:
- Continue to refine propagation technology for both laboratory culture and streamside infestation activities.
- Using refined propagation techniques, continue efforts to augment and expand the range of extant populations to ensure their viability.
- Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality.
- Determine the degree of threat that increased coal mining, and oil and gas drilling may have on this species.
- Protect habitat through acquisitions and easements.
- Assess the effects from the findings of the genetic study that found the Duck River oyster mussel should be a separate species from the Clinch and Nolichucky oyster mussels on the Recovery Plan.

- Continue efforts to educate the public about water quality and freshwater mussels.
- Establish species specific protective measures to satisfy Term and Condition #1 of the 1996 Biological Opinion, titled "Section 7 consultation and Conference Report on Surface Mining and Reclamation Operations Under Surface Mining Control and Reclamation Act of 1977", or reiniate formal Section 7 consultation to incorporate new information on listed species and the impacts of coal mining and reclamation activities and reevaluate the adequacy of the Terms and Conditions.
- Recovery Priority Number: 5.

References

Five year Review

final rule for critical habitat

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered Mussels in the Tennessee and Cumberland River Basins. Final rule. 69 FR 53136 - 53180 (August 31, 2004).

Five year review

Recovery Plan

natureserve

five year review

SPECIES ACCOUNT: *Epioblasma florentina curtisii* (Curtis pearlymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

A freshwater mussel with a shell that is small, usually lesss than 1 1/2 inches (39 mm) in length. Males are usually larger than females (mean length 31.5 mm and 28.1 mm, respectively). The ratio of shell length to shell height to shell breadth is 6:4:3. In the males, the shell is oval in shape, with ht eanterior end smoothly rounded, and the posterior end bluntly pointed and biangular. There is generally a slight but wide indentation on the posterior-ventral margin where the double, barely discernible posterior ridge joins the ventral margin. The female shell is smoothly rounded anteriorly and broadly rounded and inflated posteriorly. The posterior edge of the shell is serrated. The annual growth lines are deeply incised. The shell of both sexes is yellowish brown to brown, usually light brown, sometimes with fine, evenly spaced rays over most of its length. The beaks are broad and low and the beak sculpture is typically eroded away. Utterback (1915) describes the beak sculpture as heavily ridged, tending towards double-looped.

Historical Range

The historical range of the Curtis' pearlymussel includes the White, Black, Little Black, and Castor rivers and Cane Creek in Missouri. The Curtis' Pearlymussel has a small historical range within the Ozark Highlands and is known from the Black, St. Francis, and White river drainages in Southeast Missouri and Northeast Arkansas (USFWS 2010). At the time of the last status review in 2010, a living population could not be located. It had last been seen alive in 1993 when living specimens were observed from the Mudpuppy Conservation Area on the Little Black River (LBR) in Missouri (USFWS 2010). Since that time, only one mussel survey has been conducted within its historical range. In 2017, Schrum and Rosenburger (2018) surveyed 18 sites on the LBR in Missouri. The following LBR tributaries were also included in the survey: the South Prong Little Black River (2 sites), North Prong Little Black River (3 sites), Beaverdam Creek (2 sites), Logan Creek (2 sites), and Harris Creek (1 site). No evidence of the species was found during these efforts. Overall, they found low mussel abundance and species richness compared to previous surveys indicating that the mussel community in this stream has not yet recovered from the rapid mussel decline observed in the late 1980's and early 1990's (USFWS 2010). The Little Black River remains the last place the Curtis' Pearlymussel has been seen alive. No other information is available on the status of the species within its known range in Missouri and Arkansas. Therefore, it is still unknown whether an extant population exists. The existence of an unknown population of the Curtis' Pearlymussel is plausible where it has not been documented previously. Some streams within the White and Black river basins appear to provide suitable habitat and are in close proximity to historical streams. Further, mussel survey data is lacking for many areas. Results from several recent mussel surveys are available for some of these streams. In Missouri, the USFWS conducted mussel surveys on the Current River and Big Barren Fork Creek, which are a part of the Black River watershed (Finley et. al 2017, Drews et al. 2019). Surveys have been conducted in Arkansas within the White River Basin including the Strawberry River (Gonzalez 2018, Bouldin et al. 2013) and War Eagle (Bouldin et al. 2013), the North Fork

Sylamore, Richland, and Falling Water creeks (Bouldin et al. 2015). While mussel communities were documented in these streams, no evidence of the Curtis' Pearlymussel was found in any of these surveys (USFWS, 2010).

Current Range

When the Curtis' pearlymussel was listed as federally endangered in 1976, it had already disappeared from the White River in Missouri where it was considered to be "abundant" in historical accounts (Utterback 1917). At the time, the only extant populations known were based on a small number of collections made during the 1960's and 1970's in the Black and Castor rivers in Missouri. Utterback (1917) considered the species "scarce" in this portion of its range compared to the White River. Old museum records also existed for the Spring River and South Fork Spring River in Arkansas, but no other records existed for these streams (USFWS 1986). In 1979, a new population was discovered in a short stretch of the Little Black River (Buchanan 1979). While it occurred in assessable numbers there, it was still relatively rare. Between 1979 and 1985, over 100 living specimens were examined in the Little Black River during the course of several studies (Buchanan 1996). It was believed that this population was stable. Surveys conducted in 1981/1982 did not find any evidence of the species in the Black River, Missouri. Therefore, the only other extant population known was a small population in the Castor River, Missouri (Buchanan 1996). The status of the South Fork Spring and Spring rivers historical populations was unknown at this time. (USFWS, 2010) At the time of the last status review in 2010, a living population could not be located. It had last been seen alive in 1993 when living specimens were observed from the Mudpuppy Conservation Area on the Little Black River (LBR) in Missouri (USFWS 2010). In 2017, Schrum and Rosenburger (2018) surveyed 18 sites on the LBR in Missouri. No evidence of the species was found during these efforts. (USFWS, 2021)

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval unionid mussels require a host (typically a fish).

Juvenile: For their first several months, juvenile mussels feed using cilia (fine hairs) on the foot to capture suspended as well as depositional material, such as algae and detritus (Yeager et al. 1994, pp. 253259). Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity, when energy presumably is being diverted from growth to reproductive activities (Baird 2000, pp. 6667).

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Most mussel species have distinct forms of male and female. During reproduction, males release sperm into the water column, which females draw in through their siphons. Fertilization takes place internally, and the resulting eggs develop into specialized larvae (called glochidia) within the females modified gill pouch (called marsupia) for four to six weeks. The females will then release matured glochidia individually, in small groups, or embedded in larger mucus structures called conglutinates. Glochidia are obligate parasites (cannot live independently of their hosts) on fish and attach to the gills or fins of appropriate host species where they encyst (enclose in a cyst-like structure) and feed off of the hosts body fluids (Vaughn and Taylor 1999, p. 913) and develop into juvenile mussels weeks or months after attachment (Arey 1932, pp. 214215). The glochidia will die if they fail to find the appropriate host fish, attach to a fish that has developed immunity from prior infestations, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 299). Mussels experience their primary opportunity for dispersal and movement within the stream as glochidia attached to a host fish (Smith 1985, p. 105). Upon release from the host, newly transformed juveniles drop to the substrate on the bottom of the stream. Those juveniles that drop in unsuitable substrates die because their immobility prevents them from relocating to more favorable habitat. Juvenile freshwater mussels burrow into interstitial substrates and grow to a larger size that is less susceptible to predation and displacement from high flow events (Yeager et al. 1994, p. 220). Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. The host fish used by the Curtis' pearlymussel to complete its life cycle is uncertain. Most Epioblasma species utilize darters or sculpin species (Yeager and Saylor 1995). The tan riffleshell (E. f. walkeri), the closest relative to the Curtis' pearlymussel, was found to successfully transform in the laboratory on fantail darter (Etheostoma flabellare), greenside darter (E. blennioides), redline darter (E. rufilineatum), snubnose darter (E. simoterum), and sculpin species (genus Cottus) (Rogers et. al 2001). This is consistent with Buchanan (1987), who observed glochidia resembling Curtis' pearlymussel attached to the gills of wild rainbow darters (Etheostoma caeruleum) in the Little Black River, Missouri. To confirm the rainbow darter as a host fish for the Curtis' pearlymussel would require laboratory transformation (to identify those fish species that support successful transformation) in addition to the field data. Other darter species may also be used by the Curtis' pearlymussel as hosts. Current research has revealed fascinating interactions between Epioblasma species and their fish hosts. Freshwater mussel species use a variety of different strategies to attract fish hosts in order to facilitate the successful transfer and attachment of glochidia onto the host (Barnhart et. al 2008). For example, many species attract fish hosts by displaying or releasing lures resembling a food item of fish (Hartfield and Hartfield 1996, Barnhart and Roberts 1997). The method used by Epioblasma has only recently been discovered and has been described as "host trapping" (Barnhart et. al 2008). This strategy involves the female mussel capturing the host fish to forcefully infest the fish. To capture a host fish, gravid females lie at the surface of the substrate with the valves widely agape and mantle tissue exposed. When the mantle is touched by a fish (i.e., foraging darters) the mussel quickly closes and the fish is captured by the head between the valves of the shell. The female then expels glochidia directly onto the fish where some of the larvae attach to the gills. The infested fish is later released.

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The Curtis' pearlymussel requires good water quality and occurs in shallow stable riffles and runs. The species is limited to stream segments that are transitional between headwater and lowland streams reaches (USFWS 1986). In the White, Black, St. Francis, and Castor rivers, these transitional stream reaches either have been inundated by major reservoirs, affected by altered flows from reservoir releases, or destroyed by channelization (USFWS 1986). The recent population declines and continued lack of mussels found during recent surveys indicate that habitat conditions in the Little Black River are not currently conducive tofreshwater mussels (Bruenderman et al. 2001). While this stream appears to still have suitable physical habitat in some areas, unidentified threats continue to suppress the mussel fauna there. Only subfossil shells of the Curtis' pearlymussel have been documented in Cane Creek (USFWS 1986), and the freshwater mussel fauna was found to be very limited (Buchanan 1996). Further, no suitable habitat or mussel shells of any kind were found in 2004 (Christian Hutson, Southwest Missouri State University, in litt. 2004). Of the historical populations, only the Spring River and South Fork Spring River support diverse mussel faunas and presumably provide suitable habitat for the Curtis' pearlymussel. However, it is unknown what reaches of these streams might be transitional between headwater and lowland habitats.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:
unknown

Species Trends:
unknown

Population Growth Rate:
unknown

Number of Populations:
1 to 5, currently no extant population, last found in 1993 (USFWS, 2021)

Population Size:
1 to 1000

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Although it has never been common or widespread, the range of the Curtis' Pearly Mussel has declined significantly since the early 1900s. In 1988, monitoring results indicated that a catastrophic decline of the mussel fauna had occurred in the Little Black and Castor rivers. Additionally, no specimens of the Curtis' pearlymussel were found in the locations that were considered strongholds for the species. In 2004, all mussel survey information was evaluated by a team of mussel experts within the historical range of the Curtis' pearlymussel in Missouri and Arkansas. Stream reaches that have not been surveyed or adequately surveyed were identified. Searches were then planned to target these stream reaches as well as the entire reach of the Little Black River from where the species was last known. Between 2004 and 2007, 40 sites were surveyed in southern Missouri including the Little Black, Castor, James, and Current rivers and Big, Elbow, Shoal, Cane, Turkey, Beaver, Swan, and Bull creeks (Barnhart in prep). A total of 56 sites were surveyed in Arkansas including the Spring, South Fork Spring, Strawberry, and Eleven Point rivers (Harris et. al 2007). No evidence of the Curtis' pearlymussel was found during any of these surveys. At the present time, no extant populations of the Curtis' pearlymussel are known to occur. It appears that the last remaining population of the Curtis' pearlymussel has declined in the last 20 years to the point that the species is no longer detectable unless an unknown population exists.

Threats and Stressors

Stressor: Dams
Exposure:
Response:
Consequence:
Narrative: A major factor in the decline of freshwater mussels across the United States has been the large-scale impoundment of rivers (Vaughn and Taylor 1999, p. 913). Dams are the source of numerous threats to freshwater mussels: They block upstream and downstream movement of species by blocking host fish movement; they eliminate or reduce river flow within impounded areas, thereby trapping silts and causing sediment deposition; and dams change downstream water flow timing and temperature, decrease habitat heterogeneity, and affect normal flood patterns (Layzer et al. 1993, pp. 6869; Neves et al. 1997, pp. 6364; Watters 2000, pp. 261264; Watters 1996, p. 80). Within reservoirs (the impounded waters behind dams), the decline of freshwater mussels has been attributed to sedimentation, decreased dissolved oxygen, and alteration of resident fish populations (Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 261264). Dams significantly alter downstream water quality and stream habitats (Allan and Flecker 1993, p. 36; Collier et al. 1996, pp. 1, 7) resulting in negative effects to tailwater (the area downstream of a dam) mussel populations (Layzer et al. 1993, p. 69; Neves et al. 1997, p. 63; Watters 2000, pp. 265266). Below dams, mussel declines are associated with changes and fluctuation in flow regime, scouring and erosion of stream channels, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Williams et al. 1992, p. 7; Layzer et al. 1993, p. 69; Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 265266). Impoundments have resulted in profound changes to the nature of the rivers, primarily replacing free-flowing river systems with a series of large reservoirs.

Stressor: Sand and gravel dredging
Exposure:
Response:
Consequence:
Narrative: Sand and gravel mining (removing bed materials from streams) has been implicated in the destruction of mussel populations across the United States (Hartfield 1993, pp. 136138). Sand and gravel mining causes stream instability by increasing erosion and turbidity (a measure of water clarity) and causing subsequent sediment deposition downstream (Meador and Layher 1998, pp. 89). These changes to the stream can result in large-scale changes to aquatic fauna, by altering habitat and affecting spawning of fish, mussels, and other aquatic species (Kanehl and Lyons 1992, pp. 411).

Stressor: Contaminants/Poor water quality
Exposure:
Response:
Consequence:
Narrative: Chemical contaminants are ubiquitous throughout the environment and are a major reason for the decline of freshwater mussel species nationwide (Richter et. al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007a, p. 2029). Chemicals enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal

effluents, and agriculture runoff. These sources contribute organic compounds, heavy metals, pesticides, herbicides, and a wide variety of newly emerging contaminants to the aquatic environment. As a result, water quality can be degraded to the extent that mussel populations are adversely affected.

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Siltation and general sediment runoff is a pervasive problem in streams and has been implicated in the decline of stream mussel populations (Ellis 1936, pp. 3940; Vannote and Minshall 1982, p. 4105; Dennis 1984, p. ii; Brim Box and Mossa 1999, p. 99; Fraley and Ahlstedt 2000, pp. 193194). Specific biological effects on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills (Ellis 1936, p. 40), disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity (Marking and Bills 1979, pp. 208209; Vannote and Minshall 1982, p. 4106), physical smothering, and disrupted host fish attractant mechanisms (Hartfield and Hartfield 1996, p. 373). The primary effects of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999, p. 101). The physical effects of sediment on mussel habitats are multifold and include changes in suspended material load; changes in streambed sediment composition from increased sediment production and runoff in the watershed; changes in the form, position, and stability of stream channels; changes in water depth or the width-to-depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave mussels stranded (Brim Box and Mossa 1999, pp. 109112). Interstitial spaces (small openings between rocks and gravels) in the substrate provide essential habitat for juvenile mussels. When clogged with sand or silt, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability. Juvenile freshwater mussels burrow into interstitial substrates, making it particularly susceptible to degradation of this habitat.

Stressor: Flooding
Exposure:
Response:
Consequence:
Narrative: Significant flooding may have contributed to the decline of the Curtis' pearlymussel at least one site in the Little Black River (Buchanan 1993a). In December, 1982, flooding occurred, of unprecedented magnitude, throughout the habitat had been significantly altered (loss of substrate stability) in a ¾ mile stretch that encompassed one extant Curtis' pearlymussel site. Likewise, a significant decline in the mussel fauna was documented at this site after this flooding (Buchanan 1993a). Negative effects of major flooding also have been documented in other mussel populations where channel alterations destroyed habitat and individual animals (Hastie et al. 2001, Oliver et al. 2008).

Stressor: Drought
Exposure:
Response:
Consequence:

Narrative: Drought is another natural factor that can have devastating effects on freshwater mussels because of their inability to escape adverse environmental conditions. Riffle species like the Curtis' pearlymussel are particularly vulnerable to drought because they typically live in shallow water. Low water also allows raccoons and other small mammals that prey on mussels to gain easy access to mussel beds, thus increasing predation. Flow data are only available for the Little Black River from 1980-1986, 2007, and 2008. Of these years, stream flow was lowest in 1980 and 1981, both years prior to the 1982 flood. Other periods of low flow (below 40 cubic feet per second) occurred in August and September of 1983 and 2007. Drought, as well as extreme flooding may have contributed to the decline of the Curtis' pearlymussel population in the Little Black River.

Stressor: Climate change
Exposure:
Response:
Consequence:
Narrative: Global climate change poses a new potential threat to the Curtis' pearlymussel. Current climate change predictions for the Midwest indicate warmer air temperatures, more intense precipitation events, and increased summer drying [U.S. Global Change Research Program (GCRP) 2009]. These changes are likely to have complex and unpredictable effects upon freshwater biota, but some potential impacts related to extreme low and high water events and overall temperature changes to mussel populations are intuitive. Increased occurrence of both major flood events and drought in the Midwest would affect any remaining populations of the Curtis' pearlymussel as discussed above. Additionally, the human response to drought would be increased water withdraw from streams for crop irrigation, and thus, would further decrease water levels in streams intensifying the effects of drought.

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
Not available

Recovery Actions:
- Conduct a threats analysis of the Little Black River watershed to identify potential threats that could be contributing to the decline and continued suppression of this once diverse freshwater mussel fauna. Emphasis should be placed on identifying contaminants and potential sources of water quality degradation. This should involve bioassays using new techniques involving monitoring the survival of caged juvenile mussels (Barnhart 2006). In particular, ammonia needs to be monitored at least over the course of a year to determine temporal and spatial distribution of this pollutant in the Little Black River. If the primary stressor can be identified, removing that threat could allow the mussel fauna to begin to recover, and possibly the Curtis' pearlymussel could return to assessable numbers.
- Because the Curtis' pearlymussel has not been found in several years, searches should continue of any remaining habitat that has not been surveyed within its historical range in Missouri and Arkansas.

- Identify any areas outside of its known historical range that may have suitable transitional habitat and supporting an undiscovered population, and survey these areas if they have not been surveyed adequately.
- If a population is discovered the following actions may be appropriate: a. Confirmation of host fish b. Artificial propagation and augmentation of existing population c. Reintroduction of the species into suitable historical habitat d. Further surveys to determine extent of the population e. Analysis of watershed where the population is found to determine what threats may be affecting the population f. Update the recovery plan
- The protection of riparian areas is identified as a delisting criterion as well as a high priority recovery action in the recovery plan for the Curtis pearlymussel (USFWS 1986). In 1988, the Mudpuppy Conservation Area was purchased by the MDC. This 1,404 acre area was purchased to protect the Curtis' pearlymussel and its habitat. The area surrounds the last known extant sites for the species in the Little Black River and serves to help protect aquatic habitat in this 3.5-mile reach (MDC 2007). Additionally, the 3.5 mile reach of the Little Black River in the Mudpuppy Conservation Area was designated an outstanding resource water by the Missouri Department of Natural Resources (MDC 2007). These designated areas require more stringent water quality standards for various activities regulated under the Clean Water Act that may affect aquatic resources. However, these two measures have proven to be ineffective in protecting the species.

Conservation Measures and Best Management Practices:

- At this time, the most important management action for Curtis' Pearlymussel is to locate an extant population. Historical sites that still harbor mussels could be resurveyed to look for evidence of the species and assess the overall status of the mussel communities in those streams (e.g., Schrum and Rosenburger 2018). However, more intense efforts should focus on searching suitable habitat in historical stream reaches that have never been explored for mussel populations. Potentially, there are many miles of stream that have not been searched for mussels because past efforts have focused on Curtis' Pearlymussel sites that are easily accessible from shore. Searches should then expand to nearby streams where the species has not been documented, as unknown populations could still exist due to the lack of mussel data from some streams. These last efforts to find the Curtis' Pearlymussel may take several years to complete, but it is imperative that a population is found. Planning these efforts should employ the expertise of malacologists and other local experts to identify the most likely sites and stream reaches to expend search efforts. (USFWS, 2021).

References

Recovery Plan. USFWS. 2010. 5-YEAR REVIEW. The Curtis' Pearlymussel (Epioblasma florentina curtisii). 22 pp. Recovery Plan. USFWS. 2021. 5-YEAR REVIEW. The Curtis' Pearlymussel (Epioblasma florentina curtisii). 3 pp.

Mostly taken from U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2014 for truncilla macrodon

and five year review for curtis' pearlymussel 2010

and five year review for curtis' pearlymussel 2009

and five year review for curtis' pearlymussel 2008

Recovery Plan

Nature serve

five year review

USFWS. 2021. 5-YEAR REVIEW. The Curtis' Pearlymussel (Epioblasma florentina curtisii). 3 pp.

SPECIES ACCOUNT: *Epioblasma florentina walkeri (=E. walkeri)* (Tan riffleshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; August 23, 1977; Southeast Region (R4) (USFWS 2013)

Physical Description

E. F. walkeri is a medium-sized (7 cm) freshwater mussel with a brown to yellow colored shell with numerous green rays (NatureServe 2015).

Taxonomy

From NatureServe (2015): It has been suggested that Epioblasma capsaeformis may be a senior synonym of Epioblasma florentina walkeri (see Buhay et al., 2002), but molecular, morphological, and life history data from Jones (2004) and Jones et al. (2006) suggest they are distinct. A population from the upper Clinch River, Virginia (at Indian Creek), has been described as a separate subspecies, Epioblasma florentina aureola (Jones and Neve 2010). Variation in shell characters along with intergradation of nominal florentina and walkeri in the lower Holston River, suggest walkeri does not warrant subspecific status (Williams et al., 2008).

Historical Range

From USFWS (2013): Tan riffleshell populations were once widespread throughout the Cumberlandian Region, occurring in both the Tennessee and Cumberland Rivers and dozens of their tributary streams.

Current Range

From NatureServe (2015): This subspecies has declined severely from throughout the Cumberlandian region to only a few occurrences in the Big South Fork Cumberland River in Kentucky and Tennessee.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: From USFWS (2013): Host fishes identified through laboratory induced infections include greenside, fantail, redline, and Tennessee darters and sculpins.

Reproduction Narrative

Adult: From USFWS (2013): The life history of the species was studied in Indian Creek in the late 1990s (Rogers et al. 2001). This species is a long-term brooder with spawning putatively occurring in August and September. Most females became gravid by late fall or early winter and released glochidia principally in May and June. A study estimated fecundity in extant populations, summarized as follows: Big South Fork (n = 4), mean length = 42.1 mm, mean fecundity = 7213 (range = 1828–12,822); Indian Creek (n = 7), mean length = 29.6 mm, mean fecundity = 8068 (range = 5818–12,558) (Haag 2013). It lives at least 12 years.

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe (2015)

Habitat Narrative

Adult: From NatureServe (2015): The decline in the overall range of this species suggests that it is not tolerant of poor water quality and is sensitive to pollution, siltation, habitat perturbation, inundation, and loss of glochidial hosts. It is found in headwaters, riffles, and shoals in sand and gravel substrates. (Bogan & Parmalee, 1983)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dispersal/Migration Narrative

Adult: From NatureServe (2015): Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992).

Population Information and Trends

Population Trends:

Unknown

Number of Populations:

1 (USFWS, 2021)

Population Size:

> 2000 (NatureServe 2015)

Population Narrative:

From NatureServe (2015): The population in Indian Creek was determined to be ~2000 adults (Rogers et al., 2001). The status of the remaining populations is presently unknown due to the rarity of the mussel (Dennis in Neves, 1991).

Threats and Stressors

Stressor: Present or threatened destruction, modification, or curtailment of habitat (USFWS 2013).
Exposure:
Response:
Consequence:
Narrative: From USFWS (2013): The Recovery Plan listed impoundment, pollution, and siltation as the “major causes” for the decline of this species. The era of big dam construction appears to be over, and numbers of smaller dams are beginning to be removed (though not so much in the Cumberlandian Region). However, ongoing issues associated with the fragmentation and isolation of tan riffleshell populations from dams continue to threaten the species. A major chemical spill adjacent to the Clinch River upstream of Indian Creek occurred in 1998 that resulted in 182 dead tan riffleshell (Jones et al. 2001). Coal and natural gas extraction continues to occur in the upper portions of both watersheds that harbor extant tan riffleshell populations. Mine-related pollutants that may have contributed to the decline of the tan riffleshell (e.g., water column ammonia, arsenic and other metals in sediments) were identified by Price et al. (2011). Fecal coliform counts were high during recent sampling prompting VDEQ to put Indian Creek on its CWA Section 303d Total Maximum Daily Load (TMDL) list in 2004 based on violations of the state fecal coliform water quality criterion. Sedimentation remains a significant threat in Indian Creek, and to a lesser degree in Big South Fork.

Stressor: Climate change (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2013): Climate change will potentially have significant effects on tan riffleshell, its host fishes, and their habitats. Effects on freshwaters is already manifest in some impacts (e.g., higher temperatures, altered species ranges and phenology of aquatic organisms) (Ashizawa and Cole 1994, Parmesan 2006, Heino et al. 2009). Specific factors associated with climate change potentially affecting aquatic organisms include changes in stream temperature regimes, timing and levels of precipitation, and severity and frequency of floods and droughts (International Panel on Climate Change 2007, Galbraith et al. 2010).

Stressor: Fragmentation and isolation of small populations (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2013): Deleterious effects of population fragmentation and isolation are major concerns to imperiled mussels (reviewed in Haag 2012). Limited geographic range and rarity make tan riffleshell populations extremely vulnerable to localized extirpations due to decreased fitness from reduced genetic diversity. Further, the potential for populations to drop below the minimum viable population size threshold is a major concern for highly isolated and imperiled species. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007). Stochasticity becomes an increasing threat to small, declining populations of rare organisms (Lande et al. 2003).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. A population of Epioblasma florentina walkeri, with evidence of recent recruitment (specimens age 5 or younger), exists in the Middle Fork Holston River, Smyth and Washington Counties, VA. This population is distributed widely enough in the Middle Fork such that it is unlikely a single adverse event would result in the total loss of the population (USFWS 2013).

2. Through re-establishments and/or discoveries of new populations, a viable population exists in three additional rivers or river corridors which historically contained the species. The river (corridors) will contain at least two population centers which are dispersed to the extent that a single adverse event would be unlikely to eliminate Epioblasma florentina walkeri from its reestablished location. For a re-established population, surveys must show that three year-classes, including one year-class of age 10 or older, have been naturally produced within each of the population centers (USFWS 2013).

3. The species and its habitats are protected from present and foreseeable anthropogenic and natural threats that may interfere with the survival of any of the populations (USFWS 2013).

4. Noticeable improvements in water quality have occurred in the Middle Fork Holston River (USFWS 2013).

Recovery Actions:
- Continue to refine propagation technology and especially growout to raise juveniles in captivity to a size that vastly reduces natural mortality and readily allows tagging before release to the wild (USFWS 2013).
- The distinct populations in the Tennessee (Indian Creek) and Cumberland (Big South Fork) River drainages should be maintained separately when considering and conducting management actions. Reintroduction efforts should utilize only stock from the same respective stream drainage (USFWS 2013).
- Reintroduce populations in streams within its historical range (e.g., Tennessee River drainage—upper Clinch River, Virginia; Copper Creek, Virginia; upper North Fork Holston River, Virginia; South Fork Holston River, Virginia; Pigeon River, Tennessee; Paint Rock River, Alabama; Hurricane Creek, Alabama; Estill Fork, Alabama; Duck River, Tennessee; and lower French Broad, lower Holston, and Elk Rivers, all in Tennessee, if tailwater conditions (e.g., thermal, oxygen, flow regimes) are improved by TVA; Cumberland River drainage—Rockcastle River, Kentucky; Buck Creek, Kentucky; Clear Fork, Tennessee; Red River, Kentucky and Tennessee) that have suitable habitat and water quality conditions through the propagation of juveniles and/or release of infected host fishes. Reintroductions might be accomplished through agreements with respective states or non-essential experimental population designations, whichever method is most expedient (USFWS 2013).
- Continue to augment and expand extant populations, where warranted, through the propagation and release of cultured juveniles (USFWS 2013).
- Determine the conservation status, population demographics, and minimum viable population through periodic monitoring and research projects. Monitoring programs should be conducted in the least invasive manner practicable, to include assessing the feasibility of

monitoring primarily or solely by the mark-recapture method in conjunction with collection of gravid females for propagation and restoration purposes (USFWS 2013).
- Assess the degree of threats (e.g., coal mining, urbanization, agriculture, silviculture) to extant populations (USFWS 2013).
- Assess the effects of toxicants on all life stages from threats (e.g., coal mining, urbanization, agriculture, silviculture) (USFWS 2013).
- Assess population genetics of extant populations and introduced individuals in an attempt to ward off genetic bottlenecks and improve fitness (USFWS 2013).
- Continue monitoring water and biological parameters in Indian Creek to assess trends in its biological communities, habitat conditions, and water quality (USFWs 2013).
- Update the Tan Riffleshell Action Plan (Mollusk Recovery Group 2007) as needed and expand the scope to include its entire historical range (USFWS 2013).
- Update the Indian Creek stress analysis (TNC 2008) as needed (USFWS 2013).
- Survey Red River (USFWS 2013).
- If warranted, continue muskrat trapping in Indian Creek to reduce predation (USFWS 2013).
- Identify and implement habitat restoration projects in the Big South Fork and Indian Creek watersheds to improve instream conditions (USFWS 2013).
- Identify other streams in the species' historical range to conduct large-scale habitat restoration efforts and restore populations there (e.g., Haag and Williams 2013) (USFWS 2013).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTION Explore options to recognize golden riffleshell (Epioblasma aureola) as a distinct species separate from the tan riffleshell under the ESA. Determine the conservation status, population demographics, and viability of tan riffleshell. Continue to work with NPS on BISO mussel monitoring. Monitoring programs should be conducted in the least invasive manner practicable, to include assessing the feasibility of monitoring primarily or solely by the mark-recapture method in conjunction with collection of gravid females for propagation and restoration purposes at AWCC, FMCC, or CMC. Continue working with VDWR to monitor reintroduced individuals of the golden riffleshell. Conduct additional mussel health studies to determine how viruses and diseases are affecting the remaining individuals in the wild as well as those held in captivity. Reintroduce populations in streams through the propagation of juveniles within their historical ranges through captive propagation technologies. These rivers and streams potentially have suitable habitat and water quality conditions: tan riffleshell: Rockcastle River; Buck Creek; Clear Fork; Red River; Little South Fork; East Fork Stones River golden riffleshell: upper Clinch River; Copper Creek; upper North Fork Holston River; South Fork Holston River; Pigeon River; Citico Creek; Paint Rock River; Hurricane Creek; Estill Fork; Duck River; Elk River Identify and work with partners to implement habitat and riparian restoration projects where appropriate in Indian Creek, upper Clinch River, and Big South Fork Cumberland River watersheds to improve instream and riparian habitat conditions. Take steps to revise recovery criteria 1 and 4 for the tan riffleshell, as it is considered extirpated from the Middle Fork Holston River, and exists only in the Big South Fork Cumberland River. Work with Interior Regions 1 and 2 (Legacy Regions 4 and 5) to include recovery plan updates and/or amendments into the regional workplan. Work with Interior Region 1/Legacy Region 5, and specifically Service personnel in Virginia, to develop measurable recovery criteria for the golden riffleshell. (USFWS, 2021)

References

USFWS 2013. Tan Riffleshell Epioblasma florentina walkeri 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 18, 2016).

USFWS 2013. Tan Riffleshell Epioblasma florentina walkeri 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 18, 2016). USFWS. 2021. Tan Riffleshell Epioblasma florentina walkeri 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina. 19 pp.

USFWS. 2013. Tan Riffleshell Epioblasma florentina walkeri 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina.

USFWS 2013. Tan Riffleshell Epioblasma florentina walkeri 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office, Asheville, North Carolina.

USFWS. 2021. Tan Riffleshell Epioblasma florentina walkeri 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina. 19 pp.

SPECIES ACCOUNT: *Epioblasma obliquata obliquata* (Purple cat's paw (=Purple cat's paw pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population; 07/10/1990, 06/14/2001; Great Lakes-Big Rivers Region (R3) (USFWS, 2016)

Physical Description

The purple cat's paw has a medium-sized shell that is subquadrate in outline (Bogan and Parmalee 1983). The shell's outside surface has numerous distinct growth lines. It is yellowish-green, yellow, or brownish in color and has fine, faint, wavy green rays with a smooth and shiny surface. The shells of the young often have a satin-like surface. The inside of the shell is purplish to deep purple (the inside of the white cat's paw shell is white). For a more detailed description, see Bogan and Parmalee (1983).

Historical Range

Historically the entire species was widespread in the Ohio, Cumberland, and Tennessee River drainages in Ohio, Illinois, Indiana, Kentucky, Tennessee, and Alabama (USFWS, 1990; Hoggarth et al., 1995; Parmalee and Bogan, 1998). Cicerello and Schuster (2003) cite Kentucky distribution as formerly in the Ohio River and Green River to the Licking River.

Current Range

Now reproducing populations only exist in the Killubuck Creek, Ohio, the Cumberland River in Tennessee, and the Green River in Kentucky (USFWS, 1990). In 1992 when the recovery plan was issued, the purple cat's paw was only known to be extant in two river reaches – the middle Cumberland River in Tennessee and the Green River in Kentucky. However, no living or freshdead purple cat's paw pearlymussels have been collected in these two rivers in over 30 years. The species is likely extirpated from the Cumberland River. The species was also likely extirpated from the Green River. However, as discussed below, an effort to reestablish a purple cat's paw population in the Green River was initiated in 2017. (USFWS, 2020).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval unionid mussels require a host (typically a fish). Rock bass, mottled sculpin, stonecat, blackside darter, and logperch have been found to be fish hosts for the purple cat's paw pearlymussel (G.T. Watters, Ohio State University Museum of Biological Diversity, in litt. 1998).

Juvenile: For their first several months, juvenile mussels feed using cilia (fine hairs) on the foot to capture suspended as well as depositional material, such as algae and detritus (Yeager et al. 1994, pp. 253259). Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity, when energy presumably is being diverted from growth to reproductive activities (Baird 2000, pp. 6667).

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: The subspecies' reproductive biology remains virtually unknown, but it likely reproduces like other freshwater mussels. Males release sperm into the water column, which are taken in by the females through their siphons during feeding and respiration. The fertilized eggs are retained in the females' gills until the larvae (glochidia) fully develop. The glochidia are released into the water where they attach and encyst on the gills or fins of a fish host. When metamorphosis is complete, they drop to the streambed as juvenile mussels. Rock bass, mottled sculpin, stonecat, blackside darter, and logperch have been found to be fish hosts for the purple cat's paw pearlymussel (G.T. Watters, Ohio State University Museum of Biological Diversity, in litt. 1998).

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Little is known of this rare subspecies' life history. The purple cat's paw, which is characterized as a large-river species (Bates and Dennis 1985), has been found inhabiting water of shallow to moderate depth and with moderate to swift currents (Bogan and Parmalee 1983, Gordon and Layzer 1989). The subspecies has been reported fromboulder and sand substrates.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

3

Population Size:

1 to 250

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

The purple cat’s paw pearlymussel is a federally listed endangered subspecies that is currently known to exist in only three streams, though no individuals have been documented in two of the three streams in over 20 years. The Killbuck Creek, Ohio population, first discovered in 1994, was thought to be viable in the first few years following discovery based on sampling efforts.

However, recent search efforts aimed at collecting adult purple cat's paw for captive propagation have found that the species is now quite rare in the creek, and that the habitat conditions have declined dramatically since the 1990s.

Threats and Stressors

Stressor: Habitat degradation
Exposure:
Response:
Consequence:
Narrative: The purple cat's paw pearlymussel was historically distributed in the Ohio, Cumberland, and Tennessee River systems in Ohio, Illinois, Indiana, Kentucky, Tennessee, and Alabama (Bogan and Parmalee 1983; Isom et al. 1979; Kentucky State Nature Preserves Commission 1980; Parmalee et al. 1980; Stansbery 1970; Watters 1986). Currently, the subspecies may survive in only 3 river reaches – Killbuck Creek in Ohio, the Cumberland River in Tennessee, and the Green River in Kentucky (USFWS 1992; Hoggarth et al. 1995). Continued existence of the purple cat's paw in the Cumberland and Green Rivers is questionable as live individuals have not been reported from these rivers for over 20 years. Many of the historic populations of purple cat's paw were apparently lost when the river sections they inhabited were impounded. These impoundments seriously reduced the availability of riverine habitat and likely affected the distribution and availability of the mussel's fish hosts (USFWS 1992). The Green River in Kentucky has also experienced water quality problems related to the impacts from oil and gas production in the watershed (USFWS 1992). Ahlstedt (2007) reported that mussel habitat in Killbuck Creek is "severely degraded." The substrate is severely imbedded and relatively hard packed which doesn't allow for mussel colonization. The riparian zone is impacted by timber removal, field crops, and cattle accessing the stream. Ahlstedt (2007) also noted that "fish are noticeably absent and Asian clams were abundant" in Killbuck Creek. The Killbuck watershed also contains many operating oil and gas wells, though it is unknown if these wells are impacting the creek.

Stressor: Collection
Exposure:
Response:
Consequence:
Narrative: Any individuals that do still survive in the Cumberland River are threatened by commercial mussel fishing. Although the subspecies is not commercially valuable, incidental take of the species has occurred in the Cumberland River during commercial mussel fishing for other species (USFWS 1992).

Stressor: Climate change
Exposure:
Response:
Consequence:
Narrative: Climate change likely constitutes a threat for the species. Current climate change predictions in the Northern Hemisphere indicate warmer air temperatures and more intense precipitation events are likely to occur in the future (IPCC 2007). The predicted impacts on streams include changes in the distribution of algae, plankton, and fish, as well as changes in water temperatures and oxygen levels. Warming of waters in rivers and streams may make these

habitats less able to support their current fish and mussel fauna (IPCC 2007). Highly specialized species, such as freshwater mussels, are likely to be most susceptible to the additional stresses of a changing climate. The most recent literature on climate change includes predictions of hydrological changes, higher temperatures, and expansion of drought areas, resulting in a northward and/or upward elevation shift in range for many species (IPCC 2007). Although the specific effects of climate change on the purple cat's paw pearlymussel are unknown, altered hydrology in rivers, increased frequency of extreme weather events, and a changing abundance and distribution of fish species have the potential to adversely affect this species. The magnitude of the climate change threat to the purple cat's paw pearlymussel is unknown.

Stressor: invasive species
Exposure:
Response:
Consequence:
Narrative: Ahlstedt (2007) also noted that "fish are noticeably absent and Asian clams were abundant" in Killbuck Creek. Ahlstedt (2014) reported that Asian clams (Corbicula fluminea) appeared to have a massive die-off in 2011 but have appeared to rebound and are currently relatively common in the stream. It is interesting to note that the 2011 die-off correlates with the timing of the recent recruitment of purple cat's paw in Killbuck Creek. When Asian clam numbers were very low the purple cat's paw had successful recruitment. However, it is not known if these two events are related. However, it has been suggested that Asian clams may adversely impact native mussels by consuming a significant portion of their sperm (USFWS 1992) and that they may compete with native mussels for food and space (Sea Grant Pennsylvania, no date). (USFWS, 2020)

Recovery

Reclassification Criteria:
Criterion 1. Through protection of existing populations and successful establishment of reintroduced populations or the discovery of additional populations, a total of at least four Ohio River system tributaries contain viable populations. These populations will be distributed within the Ohio River system as follows: two populations in the upper Ohio River basin in Ohio, Indiana, or Illinois; one population in Kentucky; and one population in Tennessee. Criterion 2. Two naturally reproduced year classes exist within each of the four populations. Both year classes must have been produced within 10 years, and one year class within 5 years, of the downlisting date. Within 1 year of the downlisting date, gravid females of the subspecies and its fish host must be present in each river. Criterion 3. Biological and ecological studies have been completed, and the recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density and/or an increase in the population size and the length of the river reach inhabited within each of the populations.

Delisting Criteria:
Criterion 1. Through protection of existing populations and successful establishment of reintroduced populations or the discovery of additional populations, a total of at least six Ohio River system tributaries contain viable populations. These populations will be distributed within the Ohio River system as follows: one population in Ohio, one population in Indiana, one population in Illinois, two populations in Kentucky, and one population in Tennessee. Criterion 2. Two distinct naturally reproduced year classes exist within each of the six populations. Both

year classes must have been produced within 10 years, and one year class within 5 years, of the downlisting date. Within 1 year of the recovery date, gravid females of the subspecies and its fish host must be present in each river. Criterion 3. Studies of the mussel's biological and ecological requirements have been completed, and recovery measures developed and implemented from these studies have been successful as evidenced by an increase in population density and/or an increase in the population size and the length of the river reach inhabited within each of the six populations. Criterion 4. No foreseeable threats exist that would likely threaten survival of any of these six populations. Criterion 5. Where habitat had been degraded, noticeable improvements in water and substratum quality have occurred.

Recovery Actions:

- Prevent extinction by continuing surveys to locate individuals to initiate a captive propagation program.
- Update recovery criteria to address all of the listing factors that are relevant to the species.
- Continue to rear juveniles in captivity for future augmentation, reintroductions, and to serve as broodstock for captive propagation.
- Investigate potential sites for future augmentation or reintroduction of captivity reared juveniles and/or adults.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: Prevent extinction by continuing surveys to locate individuals to continue the captive propagation efforts. Continue to rear juveniles in captivity for future augmentation, reintroductions, and to serve as broodstock for captive propagation. Investigate potential sites for future augmentation or reintroduction of captivity reared juveniles and/or adults. Update recovery criteria to address climate change. Continue efforts to remove low head dams to improve/restore stream habitat for the purple cat's paw and its host fish. (USFWS, 2020)
- Dam removal efforts are underway on the Green River in Kentucky. In 2017, the Green River Lock & Dam 6 was removed. This restored eight additional miles of river to free-flowing condition downstream of the reintroduction locations in Mammoth Cave National Park. Efforts to remove Green River Lock & Dam 5 in the future are underway (Garland 2019, pers. comm.) Planning for the removal of the low-head Six Mile Dam on the Walhonding River in Ohio is currently underway with tentative plans for removal in 2020 (Fleece 2019, pers. comm.). The dam is located upstream of the mouth of Killbuck Creek and downstream of the purple cat's paw reintroduction site. Once removed, the dam will restore 1.06 miles of the Walhonding River to its original free flowing condition. One dam, the Mohawk Dam, would remain on the river at the convergence of the Kokosing and Mohican River where they form the Walhonding River. The Mohawk Dam is a dry dam, holding back water only during a flood and releasing it slowly downstream. (USFWS, 2020)

References

Natureserve. USFWS. 2020. Purple Cat's Paw Pearlymussel (Epioblasma obliquata obliquata). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. 21 pp.

five year review

Natureserve

USFWS. 2020. Purple Cat's Paw Pearlymussel (Epioblasma obliquata obliquata). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. 21 pp.

SPECIES ACCOUNT: *Epioblasma obliquata perobliqua* (White cat's paw (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Stansbery et al. (1982: E. o. perobligua, pg. 3) characterized this subspecies as follows: Shell small to medium size, subcompressed to subinflated, solid; male irregularly high-ovate, with a narrow shallow sulcus just anterior to the posterior ridge; female subquadrate, with a narrow, slightly swollen postventral expansion bearing a comb-like row of small, sharp denticles on its margin; female shell narrowly sulcate posterior to postventral expansion, emarginate posteriorly; umbos moderately high, sculpture double-looped; periostracum greenish yellow to greenish brown, with regular fine green rays; hinge moderate, cardinal teeth small, triangular, lateral teeth moderately thick; nacre white.

Taxonomy

The white cat's paw pearly mussel was listed as an endangered species on June 14, 1976 (41 FR 24064) under the name Epioblasma (=Dysnomia) sulcata delicata (including perobliqua) (Conrad 1836). This lengthy designation has since been shortened to Epioblasma (=Dysnomia) sulcata delicata. However, Morrison (1942) and Stansbery et al. (1982) examined the holotype of Truncilla sulcata delicata (Simpson 1900) and concluded that the specimen is an old, stunted, abnormal male of Epioblasma rangiana (Lea 1829). Therefore, since the name under which this subspecies was listed (E. s. delicata) is unavailable for the white cat's paw pearly mussel, and because Conrad's species description is more than sixty years prior to that of Simpson's, the name Epioblasma obliquata perobliqua is now recognized for this species. The species name sulcata (Lea 1829) is replaced by obliquata (Rafinesque 1820). Following Johnson (1978), Stansbery (1979) and Bogan and Parmalee (1983)

Historical Range

Epioblasma obliguata perobligua is an Ohioan or Interior Basin mollusk (Wabash River drainage) that became established in the St. Lawrence River system (Maumee River drainage) during Wisconsin glaciation. This mussel probably entered the St. Lawrence system in the same manner as many other Ohioan species; when its host, infected with the parasitic larval stage, moved from glacial Lake Maumee to the Erie River through the Wabash Outlet (Stansbery, 1961). The subspecies probably inhabited tributary streams of the Erie River at that time as well. As this river became flooded due to uplift of the Niagra Escarpment, and eventually was transformed into Lake Erie (Clarke and Stansbery, 1988), this mollusk was eliminated from these habitats and remained only in the free flowing tributary streams.

Current Range

Reproducing populations only exist in one stream (if still extant at all): Fish Creek (a tributary of the St. Joseph River), Indiana (Epioblasma obliquata perobliqua). The white cat's paw pearly mussel is currently known to exist in only a 3-mile portion of Fish Creek in Williams County in northwest Ohio (USFWS, 2021).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Larval unionid mussels require a host (typically a fish).

Juvenile: For their first several months, juvenile mussels feed using cilia (fine hairs) on the foot to capture suspended as well as depositional material, such as algae and detritus (Yeager et al. 1994, pp. 253259). Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity, when energy presumably is being diverted from growth to reproductive activities (Baird 2000, pp. 6667).

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Most mussel species have distinct forms of male and female. During reproduction, males release sperm into the water column, which females draw in through their siphons. Fertilization takes place internally, and the resulting eggs develop into specialized larvae (called glochidia) within the females modified gill pouch (called marsupia) for four to six weeks. The females will then release matured glochidia individually, in small groups, or embedded in larger mucus structures called conglutinates. Glochidia are obligate parasites (cannot live independently of their hosts) on fish and attach to the gills or fins of appropriate host species where they encyst (enclose in a cyst-like structure) and feed off of the hosts body fluids (Vaughn and Taylor 1999, p. 913) and develop into juvenile mussels weeks or months after attachment (Arey 1932, pp. 214215). The glochidia will die if they fail to find the appropriate host fish, attach to a fish that has developed immunity from prior infestations, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 299). Mussels experience their primary opportunity for dispersal and movement within the stream as glochidia attached to a host fish (Smith 1985, p. 105). Upon release from the host, newly transformed juveniles drop to the substrate on the bottom of the stream. Those juveniles that drop in unsuitable substrates die because their immobility prevents them from relocating to more favorable habitat. Juvenile freshwater mussels burrow into interstitial substrates and grow to a larger size that is less susceptible to predation and displacement from high flow events (Yeager et al. 1994, p. 220). Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. No fish hosts are known for this subspecies, but Yeager (1986) produced laboratory transformations of glochidia from Epioblasma brevidens (Lea, 1831), Epioblasma capsaeformis (Lea, 1834) and Epioblasma triquetra (Rafinesque, 1820) on darters and the banded sculpin. The host of the white cat’s paw pearly mussel is also likely tobe a riffle dwelling species such as a darter or a sculpin.

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Specific habitat requirements for E. o. perobligua are also unknown, although it has been reported most frequently from riffle-run reaches of small to moderately large rivers. Clark (1977:33) found a single living female, "lying on the surface of the gravel bottom, completely exposed." Watters (personal communication) described the habitat of the single living specimen found as completely buried in stable gravel and sand substrate. Stansbery et al. (1982) concluded that the habitat of this subspecies is similar to that of E. o. obliguata. Both are found in or on the coarse substrates of fast flowing riffles and runs.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
unknown

Number of Populations:
Last observed in 1999 (USFWS, 2021)

Population Size:
Last observed in 1999 (USFWS, 2021)

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Museum records indicate that the white cat's paw pearly mussel historically occurred in Indiana in the Wabash, White, Tippecanoe, Maumee, and St. Joseph Rivers, and Ohio in the Maumee and St. Joseph Rivers and Fish Creek. The last observation of a live white cat's paw pearly mussel occurred in 1999. Fish Creek was surveyed, system-wide, in 1975, 1988, 1996, 1999, 2004, 2005, and 2012. No mussel surveys of Fish Creek have been conducted since 2012 (USFWS, 2021).

Threats and Stressors

Stressor: Channelization
Exposure:
Response:
Consequence:
Narrative: Dredging and channelization activities have profoundly altered riverine habitats nationwide, with effects on streams summarized by Simons (1981), Bhowmik (1989), and Hubbard et al. (1993). DeHaan (1998) provided an annotated bibliography of sediment transport and deposition in large rivers. Hartfield (1993) and Neves et al. (1997) reviewed the specific effects of channelization on freshwater mollusks. Channelization impacts a stream's physical (e.g., accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, riparian canopy loss) and biological (e.g., decreased fish and mussel diversity, changed species composition and abundance, decreased biomass and growth rates) characteristics (Stansbery and Stein 1971, Hartfield 1993, Hubbard et al. 1993). Since mussels need stable substrates to survive (Strayer 1999a), channel instability is probably the single most detrimental aspect of channelization (Hartfield 1993). Channel construction for navigation has been shown to increase

flood heights (Belt 1975), thus exacerbating flood events that convey to streams large quantities of sediment with adsorbed contaminants. Channel maintenance may also result in downstream impacts (Stansbery 1970), such as increases in turbidity and sedimentation, which may smother benthic organisms. Impacts associated with barge traffic--the construction of fleeting areas, mooring cells, docking facilities, and propeller wash--also disrupt habitat.

Stressor: Gravel dredging
Exposure:
Response:
Consequence:
Narrative: Sand and gravel mining (removing bed materials from streams) has been implicated in the destruction of mussel populations across the United States (Hartfield 1993, pp. 136138). Sand and gravel mining causes stream instability by increasing erosion and turbidity (a measure of water clarity) and causing subsequent sediment deposition downstream (Meador and Layher 1998, pp. 89). These changes to the stream can result in large-scale changes to aquatic fauna, by altering habitat and affecting spawning of fish, mussels, and other aquatic species (Kanehl and Lyons 1992, pp. 411).

Stressor: Sedimentation/Siltation
Exposure:
Response:
Consequence:
Narrative: Siltation and general sediment runoff is a pervasive problem in streams and has been implicated in the decline of stream mussel populations (Ellis 1936, pp. 3940; Vannote and Minshall 1982, p. 4105; Dennis 1984, p. ii; Brim Box and Mossa 1999, p. 99; Fraley and Ahlstedt 2000, pp. 193194). Specific biological effects on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills (Ellis 1936, p. 40), disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity (Marking and Bills 1979, pp. 208209; Vannote and Minshall 1982, p. 4106), physical smothering, and disrupted host fish attractant mechanisms (Hartfield and Hartfield 1996, p. 373). The primary effects of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999, p. 101). The physical effects of sediment on mussel habitats are multifold and include changes in suspended material load; changes in streambed sediment composition from increased sediment production and runoff in the watershed; changes in the form, position, and stability of stream channels; changes in water depth or the width-to-depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave mussels stranded (Brim Box and Mossa 1999, pp. 109112). Interstitial spaces (small openings between rocks and gravels) in the substrate provide essential habitat for juvenile mussels. When clogged with sand or silt, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability. Juvenile freshwater mussels burrow into interstitial substrates, making it particularly susceptible to degradation of this habitat.

Stressor: Contaminants
Exposure:
Response:
Consequence:

Narrative: Chemical contaminants are ubiquitous throughout the environment and are a major reason for the decline of freshwater mussel species nationwide (Richter et. al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007a, p. 2029). Chemicals enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal effluents, and agriculture runoff. These sources contribute organic compounds, heavy metals, pesticides, herbicides, and a wide variety of newly emerging contaminants to the aquatic environment. As a result, water quality can be degraded to the extent that mussel populations are adversely affected.

Stressor: Global climate change
Exposure:
Response:
Consequence:
Narrative: Global climate change likely constitutes a significant new threat for the species. Current climate change predictions areas in the Northern Hemisphere indicate warmer air temperatures and more intense precipitation events (IPCC 2007). The predicted impacts on streams include changes in the distribution of algae, plankton, and fish, as well as changes in water temperatures and oxygen levels. Warming of waters in rivers and streams may make these habitats less able to support their current fish and mussel fauna (IPCC 2007). Highly specialize species, such as freshwater mussels, are likely to be most susceptible to theadditional stresses of a changing climate. The most recent literature on climate change includes predictions of hydrologicalchanges, higher temperatures, and expansion of drought areas, resulting in a northward and/or upward elevation shift in range for many species (IPCC 2007). Although the specific effects of climate change on the white cat’s paw pearly mussel are unknown, altered hydrology in rivers, increased frequency of extreme weather events, and a changing abundance and distribution of fish species have the potential to adversely affect this species. The magnitude of the climate change threat to the white cat’s paw pearly mussel may be severe since this species is only known to occur in a 3-mile reach of only one stream.

Stressor: Dams
Exposure:
Response:
Consequence:
Narrative: A major factor in the decline of freshwater mussels across the United States has been the large-scale impoundment of rivers (Vaughn and Taylor 1999, p. 913). Dams are the source of numerous threats to freshwater mussels: They block upstream and downstream movement of species by blocking host fish movement; they eliminate or reduce river flow within impounded areas, thereby trapping silts and causing sediment deposition; and dams change downstream water flow timing and temperature, decrease habitat heterogeneity, and affect normal flood patterns (Layzer et al. 1993, pp. 6869; Neves et al. 1997, pp. 6364; Watters 2000, pp. 261264; Watters 1996, p. 80). Within reservoirs (the impounded waters behind dams), the decline of freshwater mussels has been attributed to sedimentation, decreased dissolved oxygen, and alteration of resident fish populations (Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 261264). Dams significantly alter downstream water quality and stream habitats (Allan and Flecker 1993, p. 36; Collier et al. 1996, pp. 1, 7) resulting in negative effects to tailwater (the area downstream of a dam) mussel populations (Layzer et al. 1993, p. 69; Neves et al. 1997, p. 63; Watters 2000, pp. 265266). Below dams, mussel declines are associated with changes and fluctuation in flow regime, scouring and erosion of stream channels, reduced

dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Williams et al. 1992, p. 7; Layzer et al. 1993, p. 69; Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 265266). Impoundments have resulted in profound changes to the nature of the rivers, primarily replacing free-flowing river systems with a series of large reservoirs.

Stressor: Non-native plant (Honeysuckle)
Exposure:
Response:
Consequence:
Narrative: Lewis and Lewis (2015) also describe a potential threat to ICA habitat at Wednesday Cave from non-native honeysuckle species. From 2007 to 2014, they observed increasing soil erosion and siltation around and in Wednesday Cave likely caused by conversion of native vegetative species to a non-native honeysuckle monoculture. They suggest native plants retain soil but non-native honeysuckles do not, presumably due to the differences in root structure. This soil erosion led to mud slumping over the cave entrance and into the cave itself. By 2014, mud had buried the cave entrance, and they had to dig it out in order to enter the cave. Inside, they observed mud and leaves had replaced the stream habitat. They did not observe any ICA. Based on their assessment, conversion of native vegetation to non-native honeysuckles near cave entrances appears to be a threat to ICA habitat. Since only a short section of stream is accessible (Lewis 2001), we are uncertain if other sections of the stream continue to support ICA (USFWS, 2021).

Recovery

Reclassification Criteria:
Criterion 1. The population of E. o. perobliqua in Fish Creek, Williams County, Ohio is protected. This population must be large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. Criterion 2. Three additional populations are discovered or established. These populations must meet the conditions of Criterion 1. Criterion 3. The subspecies, its habitat and its host(s) are protected from any foreseeable threats that would impede the survival of any of the populations.

Delisting Criteria:
Not available

Recovery Actions:
- Prevent extinction by locating individuals to initiate a captive propagation program.
- Update recovery criteria to address all of the listing factors that are relevant to the species.
- Implement Criterion 3 - The subspecies, its habitat and its host(s) are protected from any foreseeable threats that would impede the survival of any of the populations.

References

Five year review

recovery plan

nature serve. USFWS. 2021. 5-YEAR REVIEW. White Cat’s Paw Pearly Mussel (Epioblasma obliquata perobliqua). 2 pp.

nature serve

five year review

USFWS. 2021. 5-YEAR REVIEW. White Cat’s Paw Pearly Mussel (Epioblasma obliquata perobliqua). 2 pp.

Recovery Plan

2012 five year review

SPECIES ACCOUNT: *Epioblasma penita* (Southern combshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; April 7, 1987; Southeast Region (R4) (USFWS 2015)

Physical Description

From USFWS (1989): The penitent mussel is a bivalve mollusk with adults about 55 mm (2.2 in) long, 40 mm (1.6 in) high, and 34 mm (1.4 in) wide. The shell is yellowish, greenish-yellow, or tawny, sometimes with darker dots; is rhomboid with irregular growth lines and a radially sculptured posterior (Simpson 1914). The umbos are flattened with the slope angulated; the beaks are prominent and rounded; the posterior margin flattened with a broad posterior ridge; the ligament is very short; the posterior muscular scar is very large and deep; and the nacre is white with iridescence in the spacious umbonal cavity (Conrad 1834). The species is sexually dimorphic with the posterior shell of the female expanded. The posterior margin in females is a diagonal straight line as opposed to the rounded or constricted margin of similar species (Stansbery 1983d).

Taxonomy

From USFWS (1989): The penitent mussel, Epioblasma Denita, was described by Conrad in 1834 as Unio penitus from the Alabama River (Stansbery 1983d). Other synonyms include Margarita (Unio) Denitus by Lea in 1836, Marciaron (Unio) penitus by Lea 1852, Truncilla Denita by Simpson in 1900, Dvsnomia penita by Frierson in 1927, Epioblasma Denita by Stansbery in 1976, and Placiiola penita by Johnson in 1978 (Stansbery 1983d).

Historical Range

From USFWS (1989): The penitent mussel is historically known from the Tombigbee River from the East Fork downstream to Epes, Alabama; the East Fork Tombigbee River, Mississippi; the Alabama River at Claiborne and Selma, Alabama; the Cahaba River below Centreville, Alabama; and the Coosa River in Alabama and Georgia (Stansbery 1983d, Williams 1982). Live specimens were also collected from a Tombigbee River tributary, the Buttahatchie River in Alabama and Mississippi (Vokley 1978, Schultz 1981).

Current Range

The southern combshell persists only in the Buttahatchee River of Mississippi (USFWS 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: E. penita is a filter feeder (NatureServe 2015).

Reproduction Narrative

Adult: From USFWS (1989): The reproductive cycle of freshwater mussels is similar among all species. During the spawning period, males discharge sperm into the water column, and the sperm are taken in by females during siphoning. Eggs are fertilized in the suprabranchial cavity or gills, which also serve as marsupia for larval development to mature glochidia. Freshwater mussels are long lived - up to 50 years or more. They usually reach sexual maturity in 2-4 years.From USFWS (2015): Juvenile mussels were transformed on Percina kathae (Mobile Basin Logperch) and Percina nigrofasciata (Blackbanded Darter) infected via aerial suspension from May to July 2014.

Environmental Specificity

Adult: Narrow

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: From NatureServe (2015): This species is restricted to riffles or shoals of medium sized rivers with sandy gravel to gravel-cobble substrates in moderate to swift current (USFWS, 2000).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory (NatureServe 2015)

Dispersal

Adult: Moderate

Immigration/Emigration

Adult: Emigrates

Dispersal/Migration Narrative

Adult: From NatureServe (2015): Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Strayer (1999) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that displayed little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. Movement is confined to either vertical movement burrowing deeper into sediments though rarely completely beneath the surface, or horizontal movement in a distinct path often away from the area of stimulus. Horizontal movement is generally on the order of a few meters at most and is associated with day length and during times of spawning (Amyot and Downing, 1997). Such locomotion plays little, if any, part in the distribution of freshwater mussels as these limited movements are not dispersal mechanisms. Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992).

Population Information and Trends

Population Trends:

Increasing (USFWS 2015)

Population Narrative:

USFWS (2015): Species status is stable; increase in existing population. From NatureServe (2015): Low population levels cause increased difficulty in completely successful reproduction. When individuals become scattered, the opportunity for the female to become gravid is greatly diminished. With low population levels, any impact is a major threat (USFWS, 1989). Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). The southern combshell continues to persist at multiple sites through an approximately 50-kilometer (km) reach of the Buttahatchee River in Lowndes/Monroe Counties, Mississippi (Gangloff et al. 2015; Service 2015). No comprehensive survey has been conducted since the 2015 review; however, multiple live combshells were collected from 2 sites within this area in 2019 (C. Atkinson, University of Alabama, in litt. 2020). (USFWS, 2021)

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: The primary cause of population decline for Southern combshell is habitat modification for navigation. Construction of the Tennessee-Tombigbee Waterway adversely impacted these mussels by physical destruction during dredging, increasing sedimentation, reducing water flow, and suffocating juveniles with sediment. The upper Tombigbee River was converted from a free-flowing riverine system into a series of impoundments. The remaining habitat in the mainstem Tombigbee River occurs in several bendways resulting from channel cuts. These bendways have experienced reduced flows and increased sediment accumulation (USFWS, 1989).

Stressor: Water diversion (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: Water diversion continues to threaten Southern combshell, especially in the East Fork Tombigbee River. The Tennessee-Tombigbee Waterway canal section significantly altered water flows from eastern tributaries of the East Fork. Minimum flow structures were built into the Waterway to maintain flows in tributaries from which higher flushing flood flows were diverted. At least one municipality proposes to use the East Fork as a water supply and remove up to 136 million liters or 30 million gallons (gal) per day. Unless the Waterway canal structures continually release the planned amounts of water, the withdrawal of such a large quantity of municipal water would very likely jeopardize the mussels in the East Fork. Should any other water withdrawal occur, there must be corresponding water releases from the Waterway to avoid adverse impacts to mussels. The accumulation of sediment in the East Fork downstream of Mill Creek is likely due to the diversion of flushing flows by the Waterway canal cut from Bull

Mountain Creek through the Lock B spillway some 6.4 km (4 mi) downstream (USFWS, 1989).

Stressor: Runoff of fertilizers and pesticides (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: Runoff of fertilizers and pesticides into these tributaries may adversely impact freshwater mussels. Such runoff can exceed the assimilation ability of the stream and result in algal blooms and excesses of other aquatic vegetation. This condition can produce eutrophication and result in the death of mussels. Pesticides washed into the stream are ingested by filter feeders while being transported downstream. Pesticide-laden silt particles eventually settle to and become part of the substratum, increasing the concentration of pesticides in mussel habitats (USFWS, 1989).

Stressor: Small population size (USFWS 1989, 2009)
Exposure:
Response:
Consequence:
Narrative: The low population levels cause increased difficulty for successful reproduction. When individuals are scattered, the opportunity for a female to siphon sperm and fertilize eggs is diminished. This results in fewer gravid females in proximity to the host species. With low population levels, any event that impacts one of these species is of major significance (USFWS, 1989). A single population of the southern combshell persists in the Buttahatchee River of Mississippi (USFWS, 2009).

Recovery

Reclassification Criteria:
The recovery of any of these species, to a degree that would permit down-listing to threatened, is unlikely due to their few numbers and lack of suitable habitat within their historic range (USFWS 1989).

Delisting Criteria:
Southern combshell mussel will be considered for delisting when: 1) The southern combshell population in the Buttahatchee River remains stable or increases over time, as evidenced by the presence of multiple age classes and naturally produced juveniles (Factor A). 2) At least two additional independent, self-sustaining populations are reestablished within the historical range as conditions allow, with a spatial distribution that is protective against extinction from any single catastrophic event and that provides for maintaining the adaptive potential of the species (Factors A, E). 3) Active management programs and partnerships are in place in the historically occupied drainages and have assurance of continuing for the foreseeable future. Programs must demonstrate their potential to maintain or improve habitats, provide for stability or expansion of existing or reestablished populations, and allow for species reintroduction within improved reaches (Factors A, D, and E). 4) Technology and facilities for maintaining and propagating southern combshell mussels, and regulatory mechanisms for managing and reestablishing the species within its historical range are secured (Factor D) (USFWS, 2019).

Recovery Actions:

- Continue to search for black clubshell, heavy pigtoe, and southern combshell; quantify, and monitor surviving populations and habitats (USFWS 2015).
- Complete the draft Strategic Habitat Conservation Plan for the Buttahatchee River (USFWS 2015).
- Maintain and enhance conservation partnerships within the Tombigbee drainage and Mobile River Basin (USFWS 2015).
- Develop and implement a strategic habitat conservation plan for the East Fork Tombigbee River (USFWs 2015).
- Continue to describe and monitor habitat conditions at potential reintroduction sites (USFWS 2015).
- Continue to work with States to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS 2015.
- Continue to work with AABC to propagate and reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWs 2015).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Conduct comprehensive survey for black clubshell in the East Fork Tombigbee River prior to determining extinction. 2. Continue to monitor the Buttahatchee River southern combshell population. 3. Continue to augment and monitor reintroduced southern combshell populations in the Cahaba River and Bull Mountain Creek. 4. Maintain and enhance conservation partnerships within the Tombigbee drainage and Mobile River Basin. Develop and implement a strategic habitat conservation plan for the East Fork Tombigbee River. 5. Continue to support AABC mission to propagate and reintroduce hatchery reared imperiled mollusks into restored habitats, as appropriate. (USFWS, 2021)

References

USFWS 2015. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jackson Ecological Services Field Office Jackson, Mississippi

U.S. Fish and Wildlife Service, 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 18 pp.

U.S. Fish and Wildlife Service, 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 18 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 21, 2016).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 21, 2016). USFWS. 2021. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) 5-Year Review: Summary and Evaluation – 2021. U.S. Fish and Wildlife Service South Atlantic-Gulf Region and Mississippi Basin Regions Jackson Ecological Services Field Office Jackson, Mississippi. 13 pp.

U.S. Fish and Wildlife Service. 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 18 pp.

USFWS. 2009. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum), Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli), Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum), Southern Combshell (Penitent Mussel) (Epioblasma penita), Stirrupshell (Quadrula stapes)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jackson Ecological Services Field Office Jackson, Mississippi. 24 pp.

USFWS. 2019. Amendment 1 to the U.S. Fish and Wildlife Service. 1989. Recovery Plan for: Southern Combshell Mussel (Epioblasma penita) and Black Clubshell Mussel (Pleurobema curtum).

USFWS 2015. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jackson Ecological Services Field Office, Jackson, Mississippi.

USFWS. 2021. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) 5-Year Review: Summary and Evaluation – 2021. U.S. Fish and Wildlife Service South Atlantic-Gulf Region and Mississippi Basin Regions Jackson Ecological Services Field Office Jackson, Mississippi. 13 pp.

SPECIES ACCOUNT: *Epioblasma torulosa rangiana* (Northern riffleshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 01/22/1993; Northeast Region (R5) (USFWS, 2015)

Physical Description

A freshwater mussel with males and females yellowish brown or green but much different in shape. Males oblong with a sulcus running along the posterior ridge from the umbo to the ventral margin. Females with a large expanded posterior end. Both without knobs. Nacre white, iridescent posteriorly (Cummings and Mayer, 1992) (NatureServe, 2015).

Taxonomy

Epioblasma torulosa rangiana the only remaining extant subspecies. Epioblasma is comprised of several recognized forms (torulosa, gubernaculum, rangiana, and cincinnatiensis), but it is not clear whether these forms represent ecophenotypic variation, true subspecies, or a species complex. Epioblasma was formerly placed in the genera Unio, Truncilla, and Dysnomia (NatureServe, 2015).

Historical Range

It was formerly widespread in the Ohio River basin (including Ohio River system in Ohio River at Cincinnati, Little Miami, Scioto and tribs., Muskingham, Auglaize, Sandusy, and Olentangy Rivers, and Big Darby Creek- a tributary of the Scioto; Beaver River in Ohio and Pennsylvania; Lake Erie drainage in Fish Creek, and Kanawha River, West Virginia; Wabash River and tributaries- Tippecanoe River and the Eel, Blue, and White Rivers) (Parmalee and Bogan, 1998) as well as having been collected historically from the Allegheny River drainage in Pennsylvania above Pittsburgh and from the West Fork River (Ortmann, 1913), a tributary of the Monongahela River, Harrison Co., West Virginia (Parmalee and Bogan, 1998; USFWS, 1994) (NatureServe, 2015).

Current Range

As with most naiads, its present range is a remnant of its former distribution. It is currently extant in only seven streams; the Green River in Kentucky, French and LeBoeuf Creeks and the Allegheny River in Pennsylvania, the Detroit River in Michigan (possibly extirpated- see below), and Big Darby Creek in Ohio (USFWS, 1993), and recently discovered in at least one additional river in Ontario (Metcalfe-Smith et al., 1998). It was recently found in Conewanto Creek near Warren, Warren Co., Pennsylvania, where it was previously thought to be extirpated (Evans and Smith, 2005) (NatureServe, 2015).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: The glochidia clamp down on the host tissue, and cause cells to lyse. This fluid forms part of the food for the developing parasite (Arey 1924b, 1932b; Blystad 1924) (USFWS, 1994).

Juvenile: Juveniles are relatively mobile and appear to be pedial feeders, sifting food items from sediments with cilia arranged on their foot (USFWS, 2009). Yeager et at. (1993) believed food for juveniles consisted of interstitial bacteria, yet an algal mix plus silt was suggested as food by Humphrey and Simpson (1985) and Gatenby el al. (1993) (USFWS, 1994).

Adult: Adults are filter feeders (USFWS, 2009). Allen (1914) found the gut to contain mostly diatoms and other algae, and in 1921 suggested that mussels feed on bacteria, protozoans, and organic particles. Churchill and Lewis (1924) agreed with Allen, finding that diatoms passed through the digestive system intact. Fikes (1972) maintained Amblema plicata for five months using an alga as food, but Imlay and Paige (1972) suggested that mussels fed on bacteria, protozoans, and the by-products of other food (such as fish food), rather than on the food itself (USFWS, 1994).

Reproduction Narrative

Larvae: Glochidia are discharged primarily in May and June and become encysted on a host fish where they transform into juvenile mussels over a period of days to weeks (USFWS, 2009). Estimated chances of a glochidium surviving to transform and excyst range from 0.0001% (Jansen and Hanson 1991) to 0.000001% (Young and Williams 1984) (USFWS, 1994).

Juvenile: Like other mussels, the northern riffleshell probably experiences very low annual juvenile survival (USFWS, 2009).

Adult: Clarke (1981: 352) said it was a "long-term breeder, gravid from late summer to following spring". The female uses the posterior portion of the outer gill as marsupia. Watters (1996) reports the following fish as suitable glochidial hosts: the mottled sculpin (Cottus bairdi), banded darter (Etheostoma zonale), bluebreast darter (Etheostoma camurum), and brown trout (Salmo trutta). Based upon counts of annular growth lines, this species may reach 15+ years of age. Mussel recruitment is typically low and sporadic, with population stability and viability maintained by numerous slow-growing cohorts and occasional good year classes (Neves and Widlak, 1987) (NatureServe, 2015). Rodgers et al. (2001) found that tan riffleshell males release sperm into the water in August and September, fertilizing eggs in females downstream. In addition to the species identified, there are probably other suitable fish host species; most likely several species of Etheostoma and Percina (Zanatta and Murphy 2007). Sexual maturity can be reached in 3 years (USFWS, 2009). Generally, there is only one breeding season a year (USFWS, 1994).

Geographic or Habitat Restraints or Barriers

Adult: Impoundments, lack of lotic connections, water depth > 10m (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Ortmann (1919: 334) reported that this species was "always found...on riffles, on a bottom of firmly packed and rather fine gravel, in swiftly flowing, shallow water or coarse gravel" and Clarke (1981: 362) gave its habitat as "highly oxygenated riffle". Preferred habitat appears to require swiftly moving water. The high oxygen concentrations in swift streams may be necessary for survival. The environmental specificity is very narrow; the decline in the overall range of this species suggests that it is not tolerant of poor water quality. Individuals are sensitive to pollution, siltation, habitat perturbation, inundation, and loss of glochidial hosts. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls. (NatureServe, 2015). The northern riffleshell is also known to occur in relatively slow-flowing, more lentic, or deep run habitats (USFWS, 2009).

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 1994)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015); seasonal movement (USFWS, 2009)

Dispersal

Juvenile: Moderate (inferred from USFWS, 1994)

Adult: Low (inferred from USFWS, 1994)

Dispersal/Migration Narrative

Juvenile: The host-parasite relationship apparently arose as a means of dispersal for the unionids. By attaching themselves to a highly motile host, such as a fish, they are dispersed within and between drainages (USFWS, 1994).

Adult: This species is non-migratory (NatureServe, 2015). The species appears to undergo a seasonal vertical migration in the fall (Anderson 2000) (USFWS, 2009). Freshwater mussels are essentially immotile animals (USFWS, 1994).

Population Information and Trends

Population Trends:

Decline of >90% (NatureServe, 2015)

Species Trends:

>70% decline (NatureServe, 2015)

Number of Populations:

13 (USFWS, 2019)

Population Size:

> 6,500,000 (USFWS, 2019)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

The best available information indicates that the northern riffleshell is known to currently occur in 13 populations, 4 of which are stable and recruiting. Of the four recruiting populations, three are apparently large and occur in the Allegheny River, French Creek, and East Branch Sydenham River. A fourth, smaller population occurs, as of 2006, in the Ausable River. Each of these populations is susceptible to both natural stochastic events, such as floods, and anthropogenic threats, such as toxic spills. Although northern riffleshells have been documented in one additional Allegheny River tributary (besides French Creek), and two French Creek tributaries, the species occurs in the lower reaches of these streams, and these occurrences may not be self-sustaining if the mainstem population is damaged. (USFWS, 2019). Sampling at the West Hickory bridge over the Allegheny River at West Hickory, Pennsylvania in 1999 revealed a mean density of 0.5/m2 (USGS 2004). Approximately 42,758 and 42,650 northern riffleshells were estimated to occur in 100-meter-wide river sections located 200 and 300 meters downstream, respectively, of the existing bridge (USGS 2000). Compared to the West Hickory site, northern riffleshells have been found to be more abundant both upstream and downstream, with a mean density of 1.8/m2 at five sites quantitatively sampled between Tidioute and Tionesta. Northern riffleshell populations are known from scattered locations in the middle Allegheny River (e.g., near the towns of Kennerdell, Foxburg, Oil City, Parker, and East Brady and downstream to river mile 58), where population densities are generally less than 0.1/m2 . The total population of the northern riffleshell in the Allegheny River may exceed 6,500,000 individuals (Villella 2007). (USFWS, 2019)

Threats and Stressors

Stressor: Habitat degradation (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Ongoing threats to this species include water quality degradation from point and non-point sources. The species is also affected by hydrologic and water quality alterations resulting from the operation of impoundments. A variety of instream activities continue to threaten populations, including sand and gravel dredging, gravel bar removal, bridge construction, and pipeline construction. Coal, oil, and natural gas extraction can result in increased siltation, a changed hydrograph, and altered water quality. Land-based development often results in loss of riparian habitat, increased stormwater runoff, increased sedimentation, and degradation of streambanks. Sewage effluent is also a concern (USFWS, 2009).

Stressor: Predation (USFWS, 2009)
Exposure:
Response:
Consequence:

Narrative: Due to the relatively small size of northern riffleshell, several animals prey on this mussel, including muskrats, raccoons, otters, molluscivous fish, and some invertebrates. Such predation could locally reduce populations of northern riffleshell and could represent a significant threat to small, isolated populations (USFWS, 2009).

Stressor: Zebra mussel (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Large zebra mussel populations in Lake St. Clair, the Detroit River, and Lake Erie appear to have eliminated most native mussels from the areas colonized, including northern riffleshell (USFWS, 2009).

Recovery

Reclassification Criteria:
Viable populations must be established in 10 drainages for the species; these populations should include both peripheral and central populations to maintain whatever fraction of original genetic variability is left (USFWS, 1994).

Delisting Criteria:
Each of the populations must be extensive and abundant enough~ to survive a single adverse ecological event, and the populations and their drainages must be permanently protected from all foreseeable threats (USFWS, 1994).

Recovery Actions:
- Initiate and participate in ecosystem conservation efforts (USFWS, 1994).
- Protect and manage mussel populations and their habitat on a site-specific basis (USFWS, 1994).
- Collect data on both species that are necessary for their recovery (USFWS, 1994).
- As needed, restore habitats and reintroduce the species to suitable areas (USFWS, 1994).
- Enlist public support for the recovery process through an outreach program and incentives (USFWS, 1994).
- The northern riffleshell recovery plan is more than 10 years old, and a significant amount of information has since become available regarding threats to the essential recovery streams identified in the plan. A revised plan will assist local and State entities in planning watershed and ecosystem actions to recover habitat needed for eventual relocation efforts (USFWS, 2009).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS Recommendation: Revise recovery plan. The northern riffleshell Recovery Plan is more than 20 years old, and a significant amount of information has since become available regarding threats to the essential recovery streams identified in the plan. As stated above, the recovery criteria are unclear and should be revised. A revised plan will assist local and State entities in planning watershed and ecosystem actions to recover habitat needed for eventual relocation efforts. Recommendations for specific priority recovery actions. The following recovery actions should be made a priority over the next 5 years: Priority 1 Recovery Actions: 1)

Determine sensitivity of each life stage to major contaminants likely to be found in sewage; in runoff from urban, agricultural, and energy production areas at known sites; and at potential augmentation and reintroduction sites. Develop water quality criteria recommendations for the EPA and states to protect and enhance northern riffleshell habitat. 2) Continue to monitor reintroduction and augmentation sites to determine if natural reproduction is occurring. 3) Identify and map activities or practices within each ecosystem that may affect the northern riffleshell and its host fish at known sites, and at augmentation/reintroduction sites. 4) Continue to coordinate propagation and augmentation activities between the three Service regions, and six States (including Pennsylvania, which has the source population) to maximize the chance of success and reduce any adverse effects on existing populations. Priority 2 Recovery Actions: 1) Complete surveys of the Green River and Elk River to determine if the northern riffleshell is extant in these streams. 2) If extant populations are found in Ohio River tributaries, undertake additional genetic studies to determine their relationship to Allegheny/Great Lakes populations and those remaining elsewhere in the Ohio River basin. This will increase our understanding of the species' genetic representation across its range. Priority 3 Recovery Actions: 1) To remain consistent with the current scientific understanding of this species, update the species name to Epioblasma rangiana (USFWS, 2019)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed June 2016.

USFWS 2009. Northern Riffleshell (Epioblasma torulosa rangiana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field Office

U.S. Fish and Wildlife Service. 1994. Clubshell (Pleurobema clava) and Northern Riffleshell (Epioblasma tondosa rangiana) Recovery Plan. Hadley, Massachusetts. 68 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A." USFWS. 2019. Northern Riffleshell (Epioblasma torulosa rangiana) 5-Year Review: Summary and Evaluation. 32 pp.

USFWS. 2009. Northern Riffleshell (Epioblasma torulosa rangiana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field Office.

USFWS 2009. Northern Riffleshell (Epioblasma torulosa rangiana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field Office.

USFWS. 2019. Northern Riffleshell (Epioblasma torulosa rangiana) 5-Year Review: Summary and Evaluation. 32 pp.

SPECIES ACCOUNT: *Epioblasma triquetra* (Snuffbox)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The snuffbox is a small- to medium-sized mussel, with males reaching up to 2.8 in (7.0 cm) in length (Cummings and Mayer 1992, p. 162; Parmalee and Bogan 1998, p. 108). The maximum length of females is about 1.8 in (4.5 cm) (Parmalee and Bogan 1998, p. 108). The shape of the shell is somewhat triangular (females), oblong, or ovate (males), with the valves solid, thick, and very inflated. The beaks are located somewhat anterior of the middle, and are swollen, turned forward and inward, and extended above the hingeline (Cummings and Mayer 1992, p. 162). Beak sculpture consists of three or four faint, double-looped bars (Cummings and Mayer 1992, p. 162; Parmalee and Bogan 1998, p. 108). The anterior end of the shell is rounded, and the posterior end is truncated, highly so in females. The posterior ridge is prominent, being high and rounded, while the posterior slope is widely flattened. The posterior ridge and slope in females is covered with fine ridges and grooves, and the posterioventral shell edge is finely toothed (Cummings and Mayer 1992, p. 162). The ventral margin is slightly rounded in males and nearly straight in females. Females have recurved denticles (downward curved tooth-like structures) on the posterior shell margin that aid in holding host fish (Barnhart 2008, p. 1). The periostracum (external shell surface) is generally smooth and yellowish or yellowish-green in young individuals, becoming darker with age. Green, squarish, triangular, or chevron-shaped marks cover the umbone (the inflated area of the shell along the dorsal margin), but become poorly delineated stripes with age. Internally, the left valve has two high, thin, triangular, emarginate pseudocardinal teeth (the front tooth being thinner than the back tooth) and two short, strong, slightly curved, and finely striated lateral teeth. The right valve has a high, triangular pseudocardinal tooth with a single short, erect, and heavy lateral tooth. The interdentum (a flattened area between the pseudocardinal and lateral teeth) is absent, and the beak cavity is wide and deep. The color of the nacre is white, often with a silvery luster, and a gray-blue or gray-green tinge in the beak cavity. Key characters useful for distinguishing the snuffbox from other species include its unique color pattern, shape (especially in females), and high degree of inflation.

Taxonomy

Extant populations of the snuffbox are known from 79 streams in 14 States and 1 Canadian province: Alabama (Tennessee River, Paint Rock River, and Elk River), Arkansas (Buffalo River, Spring River, and Strawberry River), Illinois (Kankakee River and Embarras River), Indiana (Pigeon River, Salamonie River, Tippecanoe River, Sugar Creek, Buck Creek, Muscatatuck River, and Graham Creek), Kentucky (Tygarts Creek, Kinniconick Creek, Licking River, Slate Creek, Middle Fork Kentucky River, Red Bird River, Red River, Rolling Fork Salt River, Green River, and Buck Creek), Michigan (Grand River, Flat River, Maple River, Pine River, Belle River, Clinton River, Huron River, Davis Creek, South Ore Creek, and Portage River), Minnesota (Mississippi River, St. Croix River), Missouri (Meramec River, Bourbeuse River, St. Francis River, and Black River), Ohio (Grand River, Ohio River, Muskingum River, Walhonding River, Killbuck Creek, Olentangy River, Big Darby Creek, Little Darby Creek, Salt Creek, Scioto Brush Creek, South Fork Scioto Brush Creek, Little Miami River, and Stillwater River), Pennsylvania (Allegheny River, French Creek, West Branch French Creek, Le Boeuf Creek, Woodcock Creek, Muddy Creek, Conneaut Outlet, Little Mahoning Creek, Shenango River, and Little Shenango River), Tennessee (Clinch River, Powell River, Elk River, and Duck River), Virginia (Clinch River and Powell River), West Virginia (Ohio River, Middle Island Creek, McElroy Creek, Little Kanawha River, Hughes River, North Fork Hughes River, and Elk River), and Wisconsin (St. Croix River, Wolf River, Embarrass River, Little Wolf River, and Willow Creek); and Ontario, Canada (Ausable River and Sydenham River). It is probable that the species persists in some of the 132 streams or lakes where it is now considered extirpated (Butler 2007, p. 16); however, if extant, these populations are likely to be small and not viable.

Historical Range

The snuffbox historically occurred in 210 streams and lakes in 18 States and 1 Canadian province: Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Missouri, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin; and Ontario, Canada. The major watersheds of historical streams and lakes of occurrence include the upper Great Lakes sub-basin (Lake Michigan drainage), lower Great Lakes sub-basin (Lakes Huron, Erie, and Ontario drainages), upper Mississippi River subbasin, lower Missouri River system, Ohio River system, Cumberland River system, Tennessee River system, lower Mississippi River sub-basin, and White River system.

Current Range

Extant populations of the snuffbox are known from 79 streams in 14 States and 1 Canadian province: Alabama (Tennessee River, Paint Rock River, and Elk River), Arkansas (Buffalo River, Spring River, and Strawberry River), Illinois (Kankakee River and Embarras River), Indiana (Pigeon River, Salamonie River, Tippecanoe River, Sugar Creek, Buck Creek, Muscatatuck River, and Graham Creek), Kentucky (Tygarts Creek, Kinniconick Creek, Licking River, Slate Creek, Middle Fork Kentucky River, Red Bird River, Red River, Rolling Fork Salt River, Green River, and Buck Creek), Michigan (Grand River, Flat River, Maple River, Pine River, Belle River, Clinton River, Huron River, Davis Creek, South Ore Creek, and Portage River), Minnesota (Mississippi River, St. Croix River), Missouri (Meramec River, Bourbeuse River, St. Francis River, and Black River), Ohio (Grand River, Ohio River, Muskingum River, Walhonding River, Killbuck Creek, Olentangy River, Big Darby Creek, Little Darby Creek, Salt Creek, Scioto Brush Creek, South Fork Scioto Brush Creek, Little Miami River, and Stillwater River), Pennsylvania (Allegheny River, French Creek, West Branch French Creek, Le Boeuf Creek, Woodcock Creek, Muddy Creek, Conneaut Outlet, Little Mahoning Creek, Shenango River, and Little Shenango River), Tennessee (Clinch River, Powell River, Elk River, and Duck River), Virginia (Clinch River and Powell River), West Virginia (Ohio River, Middle Island Creek, McElroy Creek, Little Kanawha River, Hughes River, North Fork Hughes River, and Elk River), and Wisconsin (St. Croix River, Wolf River, Embarrass River, Little Wolf River, and Willow Creek); and Ontario, Canada (Ausable River and Sydenham River). It is probable that the species persists in some of the 132 streams or lakes where it is now considered extirpated (Butler 2007, p. 16); however, if extant, these populations are likely to be small and not viable (USFWS, 2012). In 2023, a new location for snuffbox was found in a small section of the Thornapple River in Michigan near the confluence with the Grand River (Johnson 2023, pers. comm.). This is a small range expansion in the Lower Grand population. A live female snuffbox was found in Spring Creek, a tributary to the Little Kanawha River in West Virginia in 2018 (USFWS 2018). Prior to this record, the species was not known from Spring Creek. This is a small range expansion in the Little Kanawha population (USFWS, 2024).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Unionids have an unusual mode of reproduction. Their life cycle includes a brief, obligatory parasitic stage on fish. Eggs develop into microscopic larvae called glochidia within special gill chambers of the female mussel. The female expels the mature glochidia, which must attach to the gills or the fins of an appropriate fish host to complete development. Host fish specificity varies among unionids. Some species appear to use a single host, while others can transform on several host species. Following successful infestation, glochidia encyst (enclose in a cyst-like structure) and drop off as newly transformed juveniles. Snuffbox is thought to be a long-term brooders. Snuffbox brood glochidia from September to May (Ortmann 1912). Juvenile snuffbox have successfully transformed on logperch (Percina caprodes), blackside darter (P. maculata), rainbow darter, Iowa darter (E. exile), blackspotted topminnow (Fundulus olivaceous), mottled sculpin, banded sculpin (C. carolinae), Ozark sculpin (C. hypselurus), largemouth bass, and brook stickleback (Culaea inconstans) in laboratory tests (Sherman 1994, p. 17; Yeager and Saylor 1995, p. 3; Hillegass and Hove 1997, p. 25; Barnhart et al. 1998, p. 34; Hove et al. 2000, p. 30; Sherman Mulcrone 2004, pp. 100–103).

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The snuffbox is found in small- to medium-sized creeks, to larger rivers, and in lakes (Cummings and Mayer 1992, p. 162; Parmalee and Bogan 1998, p. 108). The species occurs in swift currents of riffles and shoals and wavewashed shores of lakes over gravel and sand with occasional cobble and boulders. Individuals generally burrow deep into the substrate, except when spawning or attempting to attract a host (Parmalee and Bogan 1998, p. 108). Strayer (1999a, pp. 471–472) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that display little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. Strayer thought that features commonly used in the past to explain the spatial patchiness of mussels (water depth, current speed, sediment grain size) were poor predictors of where mussels actually occur in streams.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

55 HUC 8 populations (USFWS, 2024)

Population Size:

Unknown

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Adaptability:

Low

Population Narrative:

The snuffbox has declined rangewide and appears to be extant in 79 of 210 streams and lakes of historical occurrence, a 62 percent decline in occupied streams. Realistically, much more than 62 percent of the habitat historically available for this species no longer supports its populations. Habitat losses measured in the thousands of miles have occurred rangewide. As multiple streams may comprise single snuffbox population segments (for example, the French Creek system), the actual number of extant populations is somewhat less. Extant populations, with few exceptions, are highly fragmented and restricted to short reaches. The elimination of this species from scores of streams and thousands of miles of stream reaches indicates catastrophic population losses and a precipitous decline in overall abundance. It is reasonable to estimate that total range reduction and overall population losses for the snuffbox each approximate, if not exceed, 90 percent (Final Listing Rule). The snuffbox is a federally listed endangered species that is currently considered extant in 82 streams in Alabama, Arkansas, Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Wisconsin, and Ontario, Canada. Records indicate that the species historically occurred in at least 213 streams and lakes and also historically occurred in Iowa, Kansas, Mississippi, and New York. The species has been extirpated from the lower Missouri River System and now only occurs in 7 streams in the upper Great Lakes sub-basin, 10 streams in the lower Great Lakes sub-basin, 4 streams in the upper Mississippi River sub-basin, 49 streams in the Ohio River System, 1 stream in the Cumberland River System, 6 streams in the Tennessee River System, and 5 streams in the lower Mississippi River sub-basin. Only 5 (6 percent) of the remaining populations are considered to be large and stable or improving. Four of these populations are strongholds (Bourbeuse River (MO), French Creek (PA), Clinch River (TN, VA), and Paint Rock River (AL)) and one is a significant population (St. Croix River (MN, WI). Three of the seven stronghold populations are either declining in numbers or the trend is unknown. Of the 82 extant populations, only 17 (21 percent), including all 7 of the strongholds and 10 of the significant populations, are thought to be recruiting with a high potential for having viable populations. Of the 24 significant populations, only 4 are thought to be stable or improving in numbers. Also, there are only 3 of the 24 populations that are considered to be large and 2 of the 3 are are declining in numbers. Of the 51 marginal populations, none are considered to be stable (USFWS, 2019). The current demographic and risk conditions of the 55 snuffbox HUC8 unit populations were assessed in the 2022 SSA (USFWS 2022a). Based on the demographic and risk criteria used, 17 populations (31 %) currently have a high or moderate demographic condition and only four populations are at low risk (7 %) (Table 1; Table 2). Only one population is currently in moderate condition with low risk and there are no populations with both high demographic condition and low risk (Table 3). See the 2022 SSA for a description of the demographic and risk condition categories (USFWS, 2023). The snuffbox is a federally listed endangered species that is known to be extant in 85 streams in Alabama, Arkansas, Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Wisconsin, and

Ontario, Canada. At the HUC8 unit level, these 85 occupied streams are considered to be 55 populations (USFWS, 2024).

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The decline of thesnuffbox (described by Butler 2002, 2007) is primarily the result of habitat loss and degradation (Neves 1991, p. 252). These losses have been well documented since the mid-19th century (Higgins 1858, p. 551). Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining, and sedimentation (Neves 1991, pp. 260–261; 1993, pp. 4–5; Williams et al. 1993, p. 7; Neves et al. 1997, pp. 60– 72; Watters 2000, p. 269). These stressors have had profound impacts on snuffbox populations and their habitat. Current Federal and State laws do not adequately protect snuffbox from non-point source pollution. The lack of information on the sensitivity of the snuffbox to point source discharges of common industrial and municipal pollutants prevents existing regulations, such as the Clean Water Act, from being fully used or effective. Despite the existing regulatory mechanisms, the snuffbox continue to decline due to the effects of habitat destruction, poor water quality, contaminants, and other factors. The majority of the remaining populations of the snuffbox are generally small and geographically isolated (Butler 2002, p. 26; 2007, p. 92). The patchy distributional pattern of populations in short river reaches makes those populations much more susceptible to extirpation from single catastrophic events, such as toxic chemical spills (Watters and Dunn 1993–94, p. 257). Furthermore, this level of isolation makes natural repopulation of any extirpated population virtually impossible without human intervention. Various nonnative species of aquatic organisms are firmly established in the range of the snuffbox; however, the exotic species that poses the most significant threat to the snuffbox is the zebra mussel (Dreissena polymorpha) (Butler 2002, p. 27; 2007, p. 93).

Stressor: Channelization and dredging
Exposure:
Response:
Consequence:
Narrative:

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative:

Stressor: Mining
Exposure:
Response:
Consequence:
Narrative:

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative:

Stressor: Lack of adequate regulations
Exposure:
Response:
Consequence:
Narrative:

Stressor: Small and isolated populations
Exposure:
Response:
Consequence:
Narrative:

Stressor: Invasive species (zebra mussel)
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:
Not available

Recovery Priority Number: 5.

Delisting Criteria:
Not available

Recovery Actions:
- Conservation measures provided to species listed as endangered or threatened under the Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness and conservation by Federal, State, Tribal, and local agencies, private organizations, and individuals. The Act encourages cooperation with the States and requires that recovery actions be carried out for all listed species. Recovery planning includes the development of a recovery outline shortly after a species is listed, preparation of a draft and final recovery plan, and revisions to the plan as significant new information becomes available. The recovery outline guides the immediate implementation of urgent recovery actions and describes the process to be used to develop a recovery plan. The recovery plan identifies site specific management actions that will achieve recovery of the species, measurable criteria that guide when a species may be downlisted or delisted, and methods for monitoring recovery progress. Recovery plans also establish a framework for agencies to

coordinate their recovery efforts and provide estimates of the cost of implementing recovery tasks. Recovery teams (comprised of species experts, Federal and State agencies, non-government organizations, and stakeholders) are often established to develop recovery plans.

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Develop a recovery plan for the species. 2. Maintain and increase vegetated riparian buffers of streams throughout the range of the species. 3. Initiate more watershed-level, community based riparian habitat restoration projects in streams harboring the snuffbox. 4. Investigate the U.S. Environmental Protection Agency's water quality criteria for pollutants to determine levels that would be protective of the snuffbox and other mussels. 5. Work with the U.S. Environmental Protection Agency to adjust the water quality to levels needed to protect the snuffbox (and other mussels) (see previous action). 6. Perform surveys in known streams to assess the status of known populations and to locate additional populations. 7. Rear juveniles in captivity using host fish and in-vitro techniques for future augmentation and reintroductions and develop a captive propagation and genetics management plan. 8. Investigate potential sites for future augmentation or reintroduction of captivity reared juveniles and/or adults. 9. Develop and implement a monitoring program to evaluate conservation efforts, monitor population levels and habitat conditions, and assess the long-term viability of extant, newly discovered, augmented, and reintroduced snuffbox populations (USFWS, 2019).

References

U.S. Fish and Wildlife Service. 2012. Determination of Endangered Status for the Rayed Bean and Snuffbox Mussels Throughout Their Ranges. 77 FR 30. Pps 8632-8665. February 14, 2012. USFWS. 2024. Snuffbox (Epioblasma triquetra) 5-Year Review: Evaluation and Summary. Ohio Ecological Services Field Office. Columbus, Ohio. 13 pp.

U.S. Fish and Wildlife Service. 2012. Determination of Endangered Status for the Rayed Bean and Snuffbox Mussels Throughout Their Ranges. 77 FR 30. Pps 8632-8665. February 14, 2012.

Final listing rule

U.S. Fish and Wildlife Service. 2012. Determination of Endangered Status for the Rayed Bean and Snuffbox Mussels Throughout Their Ranges. 77 FR 30. Pps 8632-8665. February 14, 2012. U.S. Fish and Wildlife Service. 2019. Snuffbox (Epioblasma triquetra). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region. Ecological Services Field Office. Columbus, Ohio. 59 pp. USFWS. 2024. Snuffbox (Epioblasma triquetra) 5-Year Review: Evaluation and Summary. Ohio Ecological Services Field Office. Columbus, Ohio. 13 pp.

U.S. Fish and Wildlife Service. 2019. Snuffbox (Epioblasma triquetra). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region. Ecological Services Field Office. Columbus, Ohio. 59 pp.

SPECIES ACCOUNT: *Fusconaia burkei* (Tapered pigtoe)

Species Taxonomic and Listing Information

Listing Status: Threatened; October 10; 2012; Southeast Region (R4) (USFWS 2012)

Physical Description

From USFWS (2012): The tapered pigtoe (Fusconaia burkei, Walker 1922) is a small to medium sized mussel endemic to the Choctawhatchee River drainage in Alabama and Florida (Williams et al. 2008, p. 296). The elliptical to subtriangular shell of the tapered pigtoe reaches about 75 mm (3.0 in.) in length, and is sculptured with plications (parallel ridges) that radiate from the posterior ridge. In younger individuals, the shell exterior is greenish brown to yellowish brown in color, occasionally with faint dark-green rays, and with pronounced sculpture often covering the entire shell; in older individuals, the shell becomes dark brown to black with age, and sculpture is often subtle. The shell interior is bluish white (Williams et al. 2008, p. 295)

Taxonomy

From USFWS (2012): The tapered pigtoe belongs to the family Unionidae. The tapered pigtoe was described by B. Walker (in Ortmann and Walker 1922) as Quincuncina burkei, a new genus and species. Genetic analysis by Lydeard et al. (2000, p. 149) determined it to be a sister taxon to Fusconaia escambia.

Historical Range

From USFWS (2012): The tapered pigtoe is endemic to the Choctawhatchee River drainage in Alabama and Florida (Williams et al. 2008, p. 296). Its historical and current distribution includes several oxbow lakes in Florida, some with a flowing connection to the main channel.

Current Range

From USFWS (2012): The narrow pigtoe still occurs in much of the known range but has disappeared from many of the tributary and main channel locations from which it was historically known. The tapered pigtoe is currently known from a total of 53 locations within the Choctawhatchee River drainage. The species persists mainly in the lower portions of the drainage and in isolated locations in Alabama. The Tapered Pigtoe's distribution has not changed significantly since the species' listing. It is endemic to the Choctawhatchee River basin, where it exists in low abundance at most locations. The species is likely extirpated in several historical reaches. New information indicates it is relatively abundant in a few high-quality streams systems, however, these populations are not sufficient to compensate for declines observed elsewhere in its range (USFWS, 2022).

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On October 10, 2012, the U.S. Fish and Wildlife Service designated critical habitat for the tapered pigtoe (Fusconaia burkei) under the Endangered Species Act of 1973, as amended (77 F 61663 - 6719).

Critical Habitat Designation

Critical habitat for the tapered pigtoe is designated in GCM6: Choctawhatchee River and Lower Pea River and GCM7: Upper Pea River.

Unit GCM6: Choctawhatchee River and Lower Pea River Drainages, Florida and Alabama. Unit GCM6 encompasses 897 km (557 mi) of the Choctawhatchee River mainstem, the lower Pea River mainstem, and 29 tributary streams in Walton, Washington, Bay, Holmes, and Jackson Counties, FL, and Geneva, Coffee, Dale, Houston, Henry, Pike, and Barbour Counties, AL. The unit consists of the Choctawhatchee River from the confluence of Pine Log Creek, Walton County, FL, upstream 200 km (125 mi) to the point the river splits into the West Fork Choctawhatchee and East Fork Choctawhatchee rivers, Barbour County, AL; Pine Log Creek from its confluence with the Choctawhatchee River, Walton County, upstream 19 km (12 mi) to the confluence of Ditch Branch, Washington and Bay Counties, FL; an unnamed channel forming Cowford Island from its downstream confluence with the Choctawhatchee River upstream 3 km (2 mi) to its upstream confluence with the river, Washington County, FL; Crews Lake from its western terminus 1.5 km (1 mi) to its eastern terminus, Washington County, FL (Crews Lake is a relic channel southwest of Cowford Island, and is disconnected from the Cowford Island channel, except during high flows); Holmes Creek from its confluence with the Choctawhatchee River, Washington County, FL, upstream 98 km (61 mi) to County Road 4, Geneva County, AL; Alligator Creek from its confluence with Holmes Creek upstream 6.5 km (4 mi) to County Road 166, Washington County, FL; Bruce Creek from its confluence with the Choctawhatchee River upstream 25 km (16 mi) to the confluence of an unnamed tributary, Walton County, FL; Sandy Creek from its confluence with the Choctawhatchee River, Walton County, FL, upstream 30 km (18 mi) to the confluence of West Sandy Creek, Holmes and Walton County, FL; Blue Creek from its confluence with Sandy Creek, upstream 7 km (4.5 mi) to the confluence of Goose Branch, Holmes County, FL; West Sandy Creek from its confluence with Sandy Creek, upstream 5.5 km (3.5 mi) to the confluence of an unnamed tributary, Walton County, FL; Wrights Creek from its confluence with the Choctawhatchee River, Holmes County, FL, upstream 43 km (27 mi) to County Road 4, Geneva County, AL; Tenmile Creek from its confluence with Wrights Creek upstream 6 km (3.5 mi) to the confluence of Rice Machine Branch, Holmes County, FL; West Pittman Creek from its confluence with the Choctawhatchee River upstream 6.5 km (4 mi) to Fowler Branch, Holmes County, FL; East Pittman Creek from its confluence with the Choctawhatchee River upstream 4.5 km (3 mi) to County Road 179, Holmes County, FL; Parrot Creek from its confluence with the Choctawhatchee River upstream 6 km (4 mi) to Tommy Lane, Holmes County, FL; the Pea River from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 91 km (57 mi) to the Elba Dam, Coffee County, AL; Limestone Creek from its confluence with the Pea River upstream 8.5 km (5 mi) to Woods Road, Walton County, FL; Flat Creek from the Pea River upstream 17 km (10 mi) to the confluence of Panther Creek, Geneva County, AL; Eightmile Creek from its confluence with Flat Creek, Geneva County, AL, upstream 15 km (9 mi) to the confluence of Dry Branch (first tributary upstream of County Road 181), Walton County, FL; Corner Creek from its confluence with Eightmile Creek upstream 5 km (3 mi) to State Route 54, Geneva County, AL; Natural Bridge Creek from its confluence with Eightmile Creek Geneva County, AL, upstream, 4 km (2.5 mi) to the Covington-Geneva County line, AL; Double Bridges Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 46 km (29 mi) to the confluence of Blanket Creek, Coffee County, AL; Claybank Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 22 km (14 mi) to the Fort Rucker military reservation southern boundary, Dale County, AL; Claybank Creek from the Fort Rucker military reservation northern boundary, upstream 6 km (4 mi) to County Road 36, Dale County, AL; Steep Head Creek from the Fort Rucker military reservation western boundary, upstream 4 km (2.5 mi) to County Road 156, Coffee County, AL; Hurricane Creek from its confluence with the Choctawhatchee River upstream 14 km (8.5 mi) to State Route 52, Geneva County, AL; Little Choctawhatchee River from its confluence with the Choctawhatchee River, Dale and Houston Counties upstream 20 km (13 mi) to the confluence of Newton Creek, Houston County, AL; Panther Creek from its confluence with the Little Choctawhatchee River, upstream 4.5 km (2.5 mi) to the confluence of Gilley Mill Branch, Houston County, AL; Bear Creek from its confluence with the Little Choctawhatchee River, upstream 5.5 km (3.5 mi) to County Road 40 (Fortner Street), Houston County, AL; West Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 54 km (33 mi) to the fork of Paul’s Creek and Lindsey Creek, Barbour County, AL; Judy Creek from its confluence with West Fork Choctawhatchee River upstream 17 km (11 mi) to County Road 13, Dale County, AL; Sikes Creek from its confluence with West Fork Choctawhatchee River, Dale County, AL, upstream 8.5 km (5.5 mi) to State Route 10, Barbour County, AL; Paul’s Creek from its confluence with West Fork Choctawhatchee River upstream 7 km (4.5 mi) to one mile upstream of County Road 20, Barbour County, AL; Lindsey Creek from its confluence with West Fork Choctawhatchee River upstream 14 km (8.5 mi) to the confluence of an unnamed tributary, Barbour County, AL; an unnamed tributary to Lindsey Creek from its confluence with Lindsey Creek upstream 2.5 km (1.5 mi) to 1.0 mile upstream of County Road 53, Barbour County, AL; and East Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 71 km (44 mi) to County Road 71, Barbour County, AL. Unit GCM6 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the Choctawhatchee River, including a potential fish host for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. Not included in this unit are two oxbow lakes now disconnected from the Choctawhatchee River main channel in Washington County, Florida. Horseshoe Lake has a record of southern kidneyshell from 1932, and Crawford Lake has records of Choctaw bean and tapered pigtoe from 1934. It is possible these oxbow lakes had some connection to the main channel when the collections were made over 75 years ago. The three species are not currently known to occur in Horseshoe or Crawford lakes, and we do not consider them essential to the conservation of the southern kidneyshell, Choctaw bean, or tapered pigtoe. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to the Elba Dam on the Pea River mainstem. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM7: Upper Pea River Drainage, Alabama. Unit GCM7 encompasses 234 km (145 mi) of the upper Pea River mainstem and six tributary streams in Coffee, Dale, Pike, Barbour, and Bullock Counties, AL. This unit is within the Choctawhatchee River basin and includes the stream segments upstream of the Elba Dam. The unit consists of the Pea River from the Elba Dam, Coffee County, upstream 123 km (76 mi) to State Route 239, Bullock and Barbour Counties, AL; Whitewater Creek from its confluence with the Pea River, Coffee County upstream 45 km (28 mi) to the confluence of Walnut Creek, Pike County, AL; Walnut Creek from its confluence with Whitewater Creek upstream 14 km (9 mi) to County Road 26, Pike County, AL; Big Creek (Coffee

County) from its confluence with Whitewater Creek, Coffee County, upstream 30 km (18 mi) to the confluence of Smart Branch, Pike County, AL; Big Creek (Barbour County) from its confluence with the Pea River upstream 10 km (6 mi) to the confluence of Sand Creek, Barbour County, AL; Pea Creek from its confluence with the Pea River upstream 6 km (4 mi) to the confluence of Hurricane Creek, Barbour County, AL; and Big Sandy Creek from its confluence with the Pea River upstream 6.5 km (4 mi) to County Road 14, Bullock County, AL. Unit GCM7 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the upper Pea River, including potential fish host(s) for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. The Elba Dam on the Pea River mainstem is a barrier to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological feature includes the absence of potential host fishes.

Primary Constituent Elements/Physical or Biological Features

Within critical habitat areas, the primary constituent elements of the physical or biological features essential to the conservation of the tapered pigtoe consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to this species and its habitat are pervasive and common in all of the nine units that are designated as critical habitat. These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Larvae: From USFWS (2012): The glochidia of most freshwater mussel species have a parasitic stage during which they must attach to the gills, fins, or skin of a fish to transform into a juvenile mussel. The blacktail shiner (Cyprinella venusta) was found to serve as a host for tapered pigtoe glochidia in the preliminary host trial (White et al. 2008, p. 122–123).

Juvenile: From USFWS (2012): Juveniles typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994, pp. 200–221; Gatenby et al. 1996, p. 604).

Adult: From USFWS (2012): Mussels siphon water into their shells and across four gills that are specialized for respiration and food collection. Food items include detritus (disintegrated organic debris), algae, diatoms, and bacteria (Strayer et al. 2004, pp. 430– 431). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column.

Reproduction Narrative

Adult: From USFWS (2012): Males release sperm into the water column, which females take in through their siphons during feeding and respiration. Fertilization takes place inside the shell. The eggs are retained in the gills of the female until they develop into mature larvae called glochidia. The reproductive biology of the tapered pigtoe was studied by White et al. (2008). It is a short-term brooder, with females gravid from mid-March to May.

Geographic or Habitat Restraints or Barriers

Adult: Impoundments (see dispersal/migration narrative)

Spatial Arrangements of the Population

Adult: Linear (USFWS 2012)

Environmental Specificity

Adult: Narrow (inferred from USFWS 2012 and NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low - moderate (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: From USFWS (2012): Freshwater mussels generally live embedded in the bottom of rivers, streams, and other bodies of water. The tapered pigtoe is found in medium creeks to medium rivers in stable substrates of sand, small gravel, or sandy mud, with slow to moderate current (Williams et al. 2008, p. 296). Habitat is linear in nature. From NatureServe (2015): Freshwater mussels are inherently vulnerable to threats from siltation, pollution, eutrophication, channelization, impoundment, collection, drought and water withdrawal, competition from invasive non-native mussels, and changes to larval host fish populations. Studies on microhabitat use in tributaries suggest the Tapered Pigtoe, Southern Sandshell, and Fuzzy Pigtoe often occur near logs and limbs and in areas with deep, fast-flowing water and consolidated sediments that remain stable during high flows Thus, important habitat characteristics for the Tapered Pigtoe include stream channels with stable substrates, natural flow regimes, and intact riparian areas (USFWS, 2022).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe (2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low - moderate (inferred from USFWS 2012 and NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (USFWS 2012)

Dispersal/Migration Narrative

Adult: From USFWS (2012): A dam or other barrier to fish passage marks the upstream extent to which mussels may disperse via their fish hosts. From NatureServe (2015): Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate although some passive movement downstream may occur during high flows.

Population Information and Trends

Population Trends:

Declining (USFWS 2012)

Number of Populations:

1 - 20 (NatureServe 2015)

Population Size:

2,500 - 100,000 (NatureServe 2015)

Additional Population-level Information:

Historically, the Tapered Pigtoe was widely distributed throughout the Choctawhatchee River basin. There is no indication that the species' distribution has changed substantially since it was listed. It remains extirpated in localized areas of the Upper Choctawhatchee subbasin, including the Little Choctawhatchee River system. Historical and current Tapered Pigtoe occurrences are shown in Figure 6. (USFWS, 2022).

Population Narrative:

From USFWS (2012): Due to its limited distribution, rarity, and habitat degradation, Blalock-Herod (2004, p. 105) considered the tapered pigtoe vulnerable to extinction, and classified it as a species of high conservation concern in Alabama. The species was not detected at 9 of the 22 historical sites examined during recent status surveys. Most of those are in the middle portion of the drainage in Alabama, and the species appears to be declining in this portion of its range. It is unknown if this species is currently experiencing a loss of genetic diversity. From NatureServe (2015): There are 1 - 20 known occurrences of this species, with a population size estimate of 2,500 - 100,000 individuals. Only 1 -12 of these populations have good viability/integrity. Tapered Pigtoe records are known from the Choctawhatchee River basin in Alabama and Florida (Fig. 6). Overall, the species exists in low abundance at most locations and appears extirpated in several historical reaches. New information indicates the species is relatively abundant in some high-quality stream systems, including Eightmile Creek (AL) and Bruce Creek (FL). Tapered Pigtoe current (2000–2021) occurrences are discussed below and summarized by subbasin in Appendix A. In the Pea subbasin, 355 live individuals have been observed since 2000. Most of these individuals (n = 285) were collected during a long-term monitoring study in Eightmile Creek, a tributary to the lower Pea River. The species is less common in the subbasin's upper reaches, where 25 live individuals were observed. Recent surveys in the Upper Choctawhatchee subbasin detected 19 individuals at 4 locations. The species is likely extirpated in many historical Upper Choctawhatchee subbasin stream systems, and the remaining populations are small and possibly isolated. The Tapered Pigtoe is widespread and appears to be maintaining populations within the Lower Choctawhatchee subbasin, where recent sampling documented at least 705 live individuals. Observations made during a long-term monitoring study in Bruce Creek (FL) found a relatively large and reproducing population (FWS unpublished data, collected from January 2015 to September 2016) (USFWS, 2022)

Threats and Stressors

Stressor: Pollution (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2012): Nonpoint-source pollution from land surface runoff originates from virtually all land use activities and includes sediments, fertilizer, herbicide and pesticide residues; animal wastes; septic tank leakage and gray water discharge; and oils and greases. Current activities and land uses that can negatively affect populations of these eight mussels include unpaved road crossings, improper silviculture and agriculture practices, highway construction, housing developments, pipeline crossings, and cattle grazing. Land surface runoff also contributes nutrients (for example, nitrogen and phosphorus from fertilizers, sewage, and

animal manure) to rivers and streams, causing them to become eutrophic. Excessive nutrient input stimulates excessive plant growth (algae, periphyton attached algae, and nuisance plants). This enhanced plant growth can cause dense mats of filamentous algae that can expose juvenile mussels to entrainment or predation and be detrimental to the survival of juvenile mussels (Hartfield and Hartfield 1996, Because of their sedentary characteristics, mussels are extremely vulnerable to toxic effluents (Sheehan et al.. 1989, pp. 139–140; Goudreau et al.1993, pp. 216–227; Newton 2003, p.2543).

Stressor: Sedimentation (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2012): Sedimentation is one of the most significant pollution problems for aquatic organisms (Williams and Butler 1994, p. 55), and has been determined to be a major factor in mussel declines (Ellis 1936, pp. 39–40). Impacts resulting from sediments have been noted for many components of aquatic communities. For example, sediments have been shown to abrade or suffocate periphyton (organisms attached to underwater surfaces); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters 1995, pp. 173– 175). When in high silt environments, mussels may keep their valves closed more often, resulting in reduced feeding activity (Ellis 1936, p. 30), and high amounts of suspended sediments can dilute their food source (Dennis 1984, p. 212). Increased turbidity from suspended sediment can reduce or eliminate juvenile mussel recruitment (Negus 1966, p. 525; Brim Box and Mossa 1999, pp. 101–102). Many mussel species use visual cues to attract host fishes; such a reproductive strategy depends on clear water. Potential sediment sources within a watershed include virtually any activity that disturbs the land surface.

Stressor: Chanel instability (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2012): Mussels require stable stream and river habitats and activities that cause channel instability can negatively impact their populations. Activities such sand and gravel mining, the removal of large woody material, off-road vehicles use, and land use changes are known to cause channel destabilization. Activities that destabilize stream beds and channels can result in drastic alterations to stream geomorphology and consequently to the stream's ecosystem.

Stressor: Impoundments (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2012): The damming of rivers has been a major factor contributing to the demise of freshwater mussels (Bogan 1993, p. 604). Dams eliminate or reduce river flow within impounded areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, affect normal flood patterns, and block upstream and downstream movement of mussels and their host fishes (Bogan 1993, p. 604; Vaughn and Taylor 1999, pp. 915–917; Watters 1999, pp. 261–264;

McAllister et al. 2000, p. iii; Marcinek et al. 2005, pp. 20–21). Downstream of dams, mollusk declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels, water temperatures, and changes in resident fish assemblages (Williams et al. 1993, p. 7; Neves et al. 1997, pp. 63–64; Watters 1999, pp. 261– 264; Marcinek et al. 2005, pp. 20–21).

Stressor: Stochastic events (UFWS 2012)
Exposure:
Response:
Consequence:
Narrative: USFWS (2012): Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may contribute to the further decline of mussel populations suffering the effects of other threats. During high flows, flood scour can dislodge mussels where they may be injured, buried, or swept into unsuitable habitats, or mussels may be stranded and perish when flood waters recede (Vannote and Minshall 1982, p. 4105;Tucker 1996, p. 435; Hastie et al. 2001,pp. 107–115; Peterson et al. 2011,unpaginated). During drought, stream channels may become disconnected pools where mussels are exposed to higher water temperatures, lower dissolved oxygen levels, and predators, or channels may become dewatered entirely. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin et al. 2002, p. 6074;Golladay et al. 2004, p. 504; Cook et al.2004, p. 1015). Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in stream temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions. The linear nature of their habitat, reduced range, and small population sizes make these eight mussels vulnerable to contaminant spills. Spills as a result of transportation accidents are a constant, potential threat as numerous highways and railroads cross the stream channels of the basins. Also, more than 400 oil wells are located within Conecuh and Escambia Counties, Alabama.

Stressor: Reduced genetic diversity (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2012): Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153).

Stressor: Nonindigenous species (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2012): The Asian clam (Corbicula fluminea) has been introduced to the drainages and may be adversely affecting this species through direct competition for space and resources. The Asian clam may pose a direct threat to native mussels, particularly as juveniles, as

a competitor for resources such as food, nutrients, and space (Neves and Widlak 1987, p. 6). Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles, and may actively disturb sediments, reducing habitable space for juvenile native mussels, or displacing them downstream (Strayer 1999, p. 82; Yeager et al. 2000, pp. 255–256). The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations. Biologists working in the Florida portions of these drainages have observed a correlation between the increase in flathead catfish numbers and a decrease in numbers of other native fish species, particularly of bullhead catfish (Ameiurus sp.) and redbreast sunfish (Lepomis auritus) (Strickland 2010 pers. comm.)

Recovery

Reclassification Criteria:
Recovery Priority Number: 11

Recovery Actions:

- From NatureServe (2015): Maintain high water and benthic habitat (substrate) qualities, as well as adequate flow regimes, throughout the Choctawhatchee River system. This may be partially accomplished via establishment of buffers and streamside management zones for all agricultural, silvicultural, mining, and developmental activities; protection of floodplain forests and adjoining upland habitat is paramount.
- From NatureServe (2015): Best management practices to follow include employing forestry practices that cause minimal soil erosion; preventing access of livestock to natural surface waters and drains; situating roads at least 0.25 mile (0.4 km) from heads of all tributaries, even more on steep slopes; using silt fencing and vegetation to control runoff and siltation at all stream crossings, especially during construction and maintenance; using and maintaining sewer systems rather than septic tanks and stream-dumping for management of wastewater; and avoiding use of agricultural pesticides on porous soils near streams.
- From NatureServe (2015): Prevent damming, dredging, and pollution throughout drainages, but especially near recorded sites. Remove existing dams, but with great care to limit downstream sedimentation.
- From NatureServe (2015): Limit withdrawal of surface and subterranean waters as necessary to maintain normal stream flows, especially during drought.
- From NatureServe (2015): Prevent or limit establishment of invasive species (including zebra mussel, Dreissena polymorpha) to the extent possible.
- From NatureServe (2015): Where appropriate, protect populations through acquisitions and easements over streamside lands by working with government agencies and conservation organizations. Also consider culture/reintroduction projects if populations decline further.

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES These seven species do not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities, which are included below. Recovery Activities a. Encourage the protection and establishment of wide riparian buffer zones along all streams containing or draining into the historical ranges of these species. Buffers of at least 300 feet in width and consisting of native forest are considered the most protective and effective. A greater width may be necessary to effectively buffer storm water runoff from urban and suburban lands, cultivated fields, and timber harvest operations. b. Restore and increase in-stream habitat and stream connectivity through conservation actions, including but not limited to removing artificial fish migration barriers, bank stabilization, riparian buffer maintenance or augmentation, improving water quality downstream of impoundments, and adherence to BMPs. c. Work with state and federal agencies and private organizations to promote land and water stewardship awareness (e.g., Soil and Water Conservation Districts, Natural Resource Conservation Service (NRCS), State Forestry Commissions, private industry groups, environmental groups, etc.). d. Develop programs and outreach materials to increase public awareness of these species and explain the benefits of protecting stream ecosystems. Monitoring and Research Activities a. Conduct status survey for Round Ebonyshell in the Conecuh River and document habitat conditions. b. Conduct surveys in under sampled portions of their ranges to examine the species' status and habitat conditions. c. Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. d. Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, and age-specific survival. e. Use eDNA as a detection tool to provide up-to-date distributional information, especially for rare or cryptic species like Southern Kidneyshell. Use assays to confirm presence in historical reaches and detect previously unknown populations. f. Conduct long-term monitoring studies of stream thermal regimes, especially during summer low flow conditions. g. Prepare a comprehensive threats assessment that identifies and maps existing and potential threats within the watersheds and identifies activities or practices that may affect the seven mussels or their habitats. Use the assessment to develop SSAs and recovery plans for the species. h. Model future precipitation, temperature, and flow scenarios in the basins to examine the impacts of climate change and consumptive uses. Use the assessment to develop SSAs and recovery plans for the species. i. Model future sea level and flow scenarios to analyze the effects of saltwater encroachment in the lower mainstems during high tide and storm surge events. Use the assessment to develop SSAs and recovery plans for the species. j. Research important life-history traits, such as host fish use, growth, longevity, age at maturity, and fecundity, and incorporate the results into management and protection actions. All partners should be aware of research efforts and results to facilitate the immediate application of results. k. Determine temperature and contaminant sensitivity for each life-stage, and develop recommendations for EPA and state water quality criteria to protect and enhance habitat. l. Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans. m. Study the life history and identify the host fish of the Southern Sandshell, Choctaw Bean, and Round Ebonyshell (USFWS, 2022).

References

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 F 61663 - 61719 (October 10, 2012).

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 23, 2016). USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 23, 2016).

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 23, 2016).

USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

SPECIES ACCOUNT: *Fusconaia cor* (Shiny pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population; 6/14/1976, 06/14/2001; Southeast Region (R4) (USFWS, 2016)

Physical Description

From USFWS (1983): This is a medium-sized species distinguished by very smooth and shiny periostracum with prominent dark green to blackish rays on a yellow to brown background (Ortmann 1918). Young specimens generally have bold black or green ray patterns whereas older specimens are dull brown in color with indistinct rays fading toward the valve margin.

Taxonomy

From USFWS (2013): The specific epithet of the shiny pigtoe was edgariana at the time of the Recovery Plan (USFWS 1984). Since that time, the specific epithet cor has been determined to represent a senior synonym and be the valid name for this taxon, relegating edgariana to junior synonym status (Turgeon et al. 1998). This name change was made under the rules set forth in the International Code of Zoological Nomenclature. There is a possibility that Fusconaia cor and the closely related and similarly endangered finerayed pigtoe, F. cuneolus, are merely phenotypic variants of a single taxon (J.W. Jones, USFWS, pers. comm., 2007). A taxonomic distinction study is needed to solve this issue.

Historical Range

From USFWS (2013): Five shiny pigtoe populations occurred at the time the 1984 Recovery Plan was written. These included Clinch (including a tributary, Copper Creek), Powell, North Fork Holston, Paint Rock, and Elk Rivers.

Current Range

From USFWS (2013): This species is currently known to occur in the Clinch River, Virginia and Tennessee; Copper Creek, Virginia; Powell River, Virginia and Tennessee; North Fork Holston River, Virginia; and Paint Rock River, Alabama.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: From USFWS (1983): Upon release into the water, mature glochidia attach to the gills and fins of appropriate host fishes to encyst and eventually metamorphose to the juvenile stage. From USFWS (2013): Host fishes identified through laboratory induced and natural infestations include common (Luxilus cornutus), striped (Luxilus chrysocephalus), telescope (Notropis telescopus), Tennessee (Notropis leuciodus), warpaint (Luxilus coccogenis), and whitetail (Cyprinella galactura) shiners (Williams et al. 2008).

Juvenile: Juveniles pedal feed on sediments in interstitial habitats (USFWS 2013).

Adult: No information available. Feeding ecology is presumed similar to Fusciona burkei. From USFWS (2012): Mussels siphon water into their shells and across four gills that are specialized for respiration and food collection. Food items include detritus (disintegrated organic debris), algae, diatoms, and bacteria (Strayer et al. 2004, pp. 430– 431). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column.

Reproduction Narrative

Adult: From USFWS (1983): The reproductive cycle of freshwater mussels appears to be similar among all species. Males discharge sperm into the water column, which are taken in by females during siphoning. From USFWS (2013): This species is a short-term brooder and is gravid from mid-June to early August (J.W. Jones, USFWS, pers. comm., 2012). It lives to at least 30 years.

Spatial Arrangements of the Population

Adult: Linear (USFWS 2015; see population narrative)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: From USFWS (1983): This is typically a riffle species, found along fords and shoals of clear, moderate to fast flowing streams and rivers with stable substrate (Bogan and Parmalee 1983). The species is usually found well buried in the substrate (Kitchel 1983). It is susceptible to stream degradation and reliant on good water quality. From NatureServe (2015): The environmental specificity of this species is narrow, as it is sensitive to changing water quality and physical disruption and does not appear tolerant of deeper water or reservoirs (USFWS, 1984).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: From NatureServe (2015): Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity.

Population Information and Trends

Population Trends:

Declining (USFWS 2013)

Number of Populations:

4 (USFWS, 2021)

Population Size:

Unknown (NatureServe 2015)

Population Narrative:

From USFWS (2013): The Clinch River drainage population has declined since the 1980s, particularly in Virginia, but has improved in recent years. This population is distributed along a total of about 80 river miles (RMs), and in addition to the lowermost reaches of Copper Creek and Little River, continues to exhibit evidence of recruitment, and represents the best population range wide. The species persists in Powell River although it has declined in abundance since the 1980s and there has been no evidence of recent recruitment. The North Fork Holston River population of the shiny pigtoe, although limited to a relatively short reach, remained sizable until about 2000 when it was decimated by a die-off of unknown cause, and is now rare there. The Paint Rock River population has also declined in recent decades but continues to recruit at a low level. The shiny pigtoe is likely extirpated from Elk River since it was last reported live in 1990. No information is currently known concerning the species’ population genetics. Generally, these shiny pigtoe populations are small, linearly distributed, and reach limited, making them especially susceptible to stochastic events, such as chemical spills. NatureServe (2015) indicates there are 6 - 20 occurrences of this species, with 1 - 12 having good viability/integrity, and an unknown population size.

Threats and Stressors

Stressor: Impoundments (USFWS 1983)
Exposure:
Response:
Consequence:
Narrative: From USFWS (1983): Dam construction in the upper Tennessee River system may have been the most significant factor contributing to the decline of the shiny pigtoe. Fuller (1974) felt that siltation was the most significant adverse effect of impoundment. Other factors detrimental

to mussel survival because of reservoirs include lowered temperatures, changes in pH, oxygen depletion, and dewatering of mussel beds.

Stressor: Siltation (USFWS 1983)
Exposure:
Response:
Consequence:
Narrative: From USFWS (1983): Silt derived from erosion in the Tennessee Valley originates from poorly implemented land use practices involving strip mining, road construction, forestry, coal mining, and agricultural operations. Mussel mortality results from feeding interference and suffocation. Siltation from solid erosion reduces light penetration, alters heat exchange, and transport organic and toxic substances to benthic areas (Ellis 1936).

Stressor: Pollution (USFWS 1983)
Exposure:
Response:
Consequence:
Narrative: From USFWS (1983): Nitrogen and phosphorus, entering streams from agricultural run-off, tend to organically enrich streams and affect mussels and their fish hosts. Imlay (1973) found that mussels could not tolerate more than 4 - 10 mg/L potassium, a pollutant associated with paper mills. Other studies have documented toxic effects on mussels from pesticides and heavy metals.

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. From USFWS (2013): A population of Fusconaia cor, with evidence of recent recruitment (specimens age 5 or younger), exists in (a) North Fork Holston River above Saltville (NFHRM 85.0), Smyth County, VA, (b) Clinch River from the backwaters of Norris Reservoir, TN, upstream to Nash Ford (CRM 280), Russell County, VA, (c) Powell River from the backwaters of Norris Reservoir, TN, upstream to Flanary Bridge (PRM 130), Lee County, VA, (d) Elk River in Lincoln County, TN, (e) Paint Rock River in Jackson County, AL, and (f) Copper Creek, Scott County, VA. These populations are distributed widely enough within their rivers such that it is unlikely a single adverse event in a river would result in the total loss of that population.

2. From USFWS (2013): Through re-establishments and/or discoveries of new populations, a viable population exists in one additional river or two river corridors which historically contained the species. The river (corridors (or parts of a river where the mussel was historically found)) will contain at least two population centers which are dispersed to the extent that a single adverse event would be unlikely to eliminate Fusconaia cor from its re-established location. For a re-established population, surveys must show that three year-classes, including one year-class of age 10 or older, have been naturally produced within each of the population centers

3. From USFWS (2013): The species and its habitats are protected from present and foreseeable anthropogenic and natural threats that may interfere with the survival of any of the

populations.

4. From USFWS (2013): Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal or other energy related impacts exists in the Clinch River.

Recovery Actions:

- Preserve populations and habitats of F. cor in the North Fork Holston, Clinch, Powell, Elk, and Paint Rock Rivers and in Copper Creek (USFWS 1983).
- Conduct life history research on the species, to include gametogenesis, fish host identification, age class structure, growth rate, life tables, and mortality factors (USFWS 1983).
- Determine the feasibility of introducing the species into one additional river or establishing new population centers in two rivers where it currently resides; implement such activities where feasible (USFWS 1983).
- Outline and implement a schedule to monitor population levels and trends in extant and introduced populations and population centers (USFWS 1983).
- Evaluate the success of individual activities and overall success of the recovery program; recommend revisions or additional actions as necessary to recover the species (USFWS 1983).
- Develop juvenile propagation and growout technology.
- Reintroduce individuals through release of propagated juveniles and/or release of infected host fishes in other streams within the historical range (e.g., Nolichucky, upper Holston, Pigeon, and Little (Tennessee) Rivers; Tennessee River below Wilson Dam; possibly lower French Broad/Holston and Elk Rivers if thermal, oxygen, and flow regimes are corrected) that have suitable habitat and water quality conditions.
- Augment and expand extant populations through release of propagated juveniles and/or release of infected host fishes.
- Determine how much genetic variation is sufficient to maintain long term population viability
- Determine the degree of threat (especially coal mining in Clinch and Powell Rivers) to each stream in which this species occurs.
- Determine extent and viability of all currently known populations.
- Survey for and assess populations of potential host fishes in the NEP tailwaters in Tennessee River, lower French Broad and Holston Rivers, and other potential reintroduction sites.
- Conduct a taxonomic distinctiveness study to determine the validity of this species and its relatedness to the finerayed pigtoe, Fusconaia cuneolus.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTION The 2013 five-year review included a list of recommendations to improve recovery of the shiny pigtoe; these actions remain applicable to species recovery. Additional recommendations are incorporated below: • Develop propagation technology and culture techniques for the shiny pigtoe and other short-term brooding species. Initial efforts are already underway by VDWR. • Reassess status and viability of currently known populations every five years. Additionally, conduct targeted surveys within rivers to develop population estimates and effective population size targets. Continue long-term monitoring in the Clinch River and ongoing studies to identify potential mussel viruses and diseases which may be associated with recent die-off events. • Work with TVA, TWRA, VDWR, and other partners to gather quantitative and qualitative mussel community data and monitor threats in the Elk River, Tennessee and Copper Creek, Virginia. • Evaluate flow release benefits from improved operations at Tims Ford Dam, Elk River, to assess the benefits of naturally variable seasonal flows, temperatures, and associated DO level increases on freshwater mussels. Continue mussel monitoring and riparian restoration efforts in the Elk River and Copper Creek and explore ways to improve instream habitat conditions. • Reintroduce populations through propagation of juveniles in other rivers within the historical range that have potential for viability (e.g., Holston, French Broad, Elk River and the Tennessee River below Wilson Dam). (USFWS, 2021)

References

USFWS 2013. Shiny Pigtoe Fusconaia cor 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina

USFWS 2007. Endangered and Threatened Wildlife and Plants

Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee

Final Rule. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461

USFWS 1983. Shiny Pigtoe Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 67 pp.

USFWS 1983. Shiny Pigtoe Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 67 pp

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

USFWS 1983. Shiny Pigtoe Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 67 pp.

U.S. Fish and Wildlife Service. 1983. Shiny Pigtoe Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 67 pp.

USFWS 2013. Shiny Pigtoe Fusconaia cor 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office, Asheville, North Carolina

USFWS. 2021. Shiny Pigtoe Fusconaia cor 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina.

40 pp.

SPECIES ACCOUNT: *Fusconaia cuneolus* (Finerayed pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population; 6/14/1976, 06/14/2001; Southeast Region (R4) (USFWS, 2016)

Physical Description

From USFWS (1984): F. cuneolus is a medium-sized species usually distinguished by periostracum with fine green rays on a yellow-green to brown (old specimens) background. Indistinct growth checks and a satin-like appearance characterize the shell surface.

Taxonomy

In an unpublished study of molecular systematics, Campbell and Harris (2006) found this species was closely related to Fusconaia cor but was distinct (NatureServe 2015).

Historical Range

Seven populations of the finerayed pigtoe occurred at the time the 1984 Recovery Plan was written. These populations included the Clinch (including two Virginia tributaries, Copper Creek and Little River), Powell, North Fork Holston (including a tributary, Possum Creek), Little (Tennessee), Sequatchie, Paint Rock, and Elk Rivers (USFWS 2013).

Current Range

Currently, this species is known or believed to occur in the Clinch River, Virginia and Tennessee; Copper Creek, Virginia; Little River, Virginia; Powell River, Virginia and Tennessee; North Fork Holston River, Virginia and Tennessee; Possum Creek, Virginia; Little River, Tennessee; and Paint Rock River, Alabama (USFWS 2013).

Critical Habitat Designated

No;

Life History

Feeding Narrative

<u>Adult:</u> No information available. Feeding ecology is presumed similar to Fusciona burkei. From USFWS (2012): Mussels siphon water into their shells and across four gills that are specialized for respiration and food collection. Food items include detritus (disintegrated organic debris), algae, diatoms, and bacteria (Strayer et al. 2004, pp. 430– 431). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column.

Reproduction Narrative

<u>Adult:</u> From USFWS (1984): The reproductive cycle of freshwater mussels appears to be similar among all species. Males discharge sperm into the water column, which are taken in by females during siphoning. F. cuneolus is a short-term breeder, with all four gills serving as marsupia in females. Ortmann (1921) reported gravid females from May to July. From USFWS (2013): Upon release into the water column, mature glochidia attach to the gills and fine of appropriate host fishes to encyst and eventually metamorphose to the juvenile stage. Host fishes identified

through natural and laboratory-induced infections include river chub (Nocomis micropogon); whitetail (Cyprinella galactura), white (Luxilus albeolus), telescope (Notropis telescopus), and Tennessee (Notropis leuciodus) shiners; central stoneroller (Campostoma anomalum); mottled sculpin (Cottus bairdii); and fathead minnow (Pimephales promelas). This species lives to approximately 35 years.

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 1984)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: F. cuneolus is typically a riffle species that inhabits ford and shoal areas in free-flowing streams of moderate gradient. It has been collected from sandy, rocky, and sandy-muddy substrates (Hickman 1937, Ortmann 1925). This species is apparently intolerant of lentic conditions and is usually well-buried in the substrate (USFWS 1984). This species has a narrow environmental specificity, as it is sensitive to changes in water quality (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: From NatureServe (2015): Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity.

Population Information and Trends

Population Trends:
Declining (USFWS 2013)

Number of Populations:
7 (USFWS, 2022)

Population Size:
Unknown (NatureServe 2015)

Population Narrative:
From USFWS (2013): The Clinch River drainage population has declined since the 1980s, particularly in Virginia, but has improved in recent years. This population is distributed along a total of about 80 river miles (RMs), in addition to the lowermost reaches of Copper Creek and Little River, continues to exhibit evidence of recruitment, and represents the only clearly viable population rangewide. In Powell River the species was relatively uncommon in the 1980s but has further declined to the point of being possibly extirpated or if extant has declined to nearly undetectable levels. The population in North Fork Holston River persists in the vicinity of the Virginia/Tennessee state line and has recently been discovered in a Virginia tributary in this reach, Possum Creek. The species is very rare in the North Fork Holston River drainage and there is no evidence of recent recruitment, making its status there very tenuous. Only two individuals have ever been collected in Little River, Tennessee; the status of that population in unknown. The Paint Rock River population was rare in the 1980s but has further declined to the point where if it persists it may do so at nearly undetectable levels. The finerayed pigtoe is considered extirpated from Sequatchie and Elk Rivers given that no evidence of its occurrence has been detected in either stream since about 1980. No information is currently known concerning the species’ population genetics.NatureServe (2015) indicates there are 1 - 5 occurrences of this species, with 1 - 3 having good viability/integrity, and an unknown population size.

Threats and Stressors

Stressor: Small, isolated populations (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: From USFWS (2013): Rare species with small, highly disjunct populations like the finerayed pigtoe may suffer various threats from inherently small population size (summarized in USFWS 2004). Limited geographic range and rarity make its populations extremely vulnerable to localized extinctions from stochastic disturbances and decreased fitness from reduced genetic diversity. Potential sources of such disturbances include accidental spills involving vehicles transporting chemicals over roadway stream crossings inhabited by the finerayed pigtoe and accidental or intentional release of chemicals used in agricultural or residential applications. Impoundments, spills, and other human-induced changes are a significant threat to aquatic organisms due to the genetic concerns associated with small, geographically isolated populations.

Stressor: Impoundments (USFWS 1984)
Exposure:
Response:
Consequence:
Narrative: From USFWS (1984): Dam construction in the upper Tennessee River system may have been the most significant factor contributing to the decline of the shiny pigtoe. Fuller (1974) felt that siltation was the most significant adverse effect of impoundment. Other factors detrimental to mussel survival because of reservoirs include lowered temperatures, changes in pH, oxygen depletion, and dewatering of mussel beds.

Stressor: Siltation (USFWS 1984)
Exposure:
Response:
Consequence:
Narrative: From USFWS (1984): Silt derived from erosion in the Tennessee Valley originates from poorly implemented land use practices involving strip mining, road construction, forestry, coal mining, and agricultural operations. Mussel mortality results from feeding interference and suffocation. Siltation from solid erosion reduces light penetration, alters heat exchange, and transport organic and toxic substances to benthic areas (Ellis 1936).

Stressor: Pollution (USFWS 1984)
Exposure:
Response:
Consequence:
Narrative: From USFWS (1984): Nitrogen and phosphorus, entering streams from agricultural run-off, tend to organically enrich streams and affect mussels and their fish hosts. Imlay (1973) found that mussels could not tolerate more than 4 - 10 mg/L potassium, a pollutant associated with paper mills. Other studies have documented toxic effects on mussels from pesticides and heavy metals.

Recovery

Reclassification Criteria:
No downlisting criteria are given in the recovery plan (USFWS 2007).

Recovery Priority Number: 5

Delisting Criteria:
1. A population of the finerayed pigtoe, with evidence of recent recruitment (specimens age 5 or younger), exists in (a) North Fork Holston River, Hawkins County, TN, (b) Powell River between Buchanan Ford (PRM 99.2), Claiborne County, TN, and Fletcher Ford (PRM 117.4), Lee County, VA, (c) Clinch River between Kelly Branch (CRM 155.7), Claiborne County, TN, and Cedar Bluff (CRM 322.6), Tazewell County, VA, (d) Little River, Russell County, VA, and Copper Creek, Scott County, VA (tributaries of Clinch River), (e) Elk River between ERM 70.5 and ERM 105.4, Lincoln County, TN, (f) Paint Rock River, Jackson County, AL, and (g) Sequatchie River, Sequatchie County, TN. These populations are distributed widely enough within their rivers such that a single adverse event in a river would be unlikely to result in the total loss of that population

(USFWS 2013).

2. Through re-establishment and/or discoveries of a new population, a viable population exists in one additional stream/river or stream/river corridor that historically maintained the species. The viable population will contain at least two population centers which are dispersed to the extent that a single adverse event would be unlikely to eliminate the finerayed pigtoe from its newly discovered or re-established location. Mussel surveys must document that three year-classes, including one year-class of age 10 or older, have been naturally produced within each of the population centers (USFWS 2013).

3. The species and its habitats are protected from present and foreseeable anthropogenic and natural threats that may interfere with the survival of any of the populations (USFWS 2013).

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal or other energy related impacts occurs in the Clinch River (USFWS 2013).

Recovery Actions:

- Preserve populations and habitats of F. cuneolus in the North Fork Holston, Powell, Clinch, (including tributaries Little River and Copper Creek), Elk, Paint Rock, and Sequatchie Rivers (USFWS 1984).
- Conduct life history research on the species, to include gametogenesis, fish host identification, age class structure, growth rate, life tables, and mortality factors (USFWS 1984).
- Determine the feasibility of introducing the species into one additional stream/river or establishing a viable population in an appropriate section of a stream/river where it currently resides; implement such an activity where feasible (USFWS 1984).
- Outline and implement a schedule to monitor population levels and trends in extant and introduced populations and population centers (USFWS 1984).
- Evaluate the success of the recovery program; recommend revisions or additional actions as necessary to recover the species (USFWS 1984).
- Develop juvenile propagation and growout technology (USFWS 2013).
- Reintroduce individuals through release of propagated juveniles and/or release of infected host fishes in other streams within the historical range (e.g., Nolichucky, upper Holston, Pigeon, and Little (Tennessee) Rivers; Tennessee River below Wilson Dam; possibly lower French Broad/Holston and Elk Rivers if thermal, oxygen, and flow regimes are corrected) that have suitable habitat and water quality conditions (USFWS 2013).
- Augment and expand extant populations through propagation of juveniles and/or release of infected host fishes (USFWS 2013).
- Determine how much genetic variation is sufficient to maintain long term population viability (USFWS 2013).
- Determine the degree of threat (especially coal mining in Clinch and Powell Rivers) to each stream in which this species occurs (USFWS 2013).
- Determine extent and viability of all currently known populations (USFWS 2013).
- Survey for and assess populations of potential host fishes in the NEP tailwaters in Tennessee River, lower French Broad and Holston Rivers, and other potential reintroduction sites (USFWS 2013).

- Conduct a taxonomic distinctiveness study to determine the validity of this species and its relatedness to the shiny pigtoe, Fusconaia cor. (USFWS 2013).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The 2013 five-year review included a list of recommendations to improve recovery of the finerayed pigtoe; these actions remain applicable to species recovery. • Develop juvenile propagation and growout technology. • Reintroduce individuals through release of propagated juveniles and/or release of infected host fishes in other streams within the historical range (e.g., Nolichucky, upper Holston, Pigeon, and Little (Tennessee) rivers; Tennessee River below Wilson Dam; possibly lower French Broad/Holston and Elk rivers if thermal, oxygen, and flow regimes are corrected) that have suitable habitat and water quality conditions. • Augment and expand extant populations through propagation of juveniles. • Determine how much genetic variation is sufficient to maintain long term population viability. • Determine the degree of threat (especially coal mining in Clinch and Powell rivers) to each stream in which this species occurs. • Determine extent and viability of all currently known populations. • Survey for and assess populations of potential host fishes in the NEP tailwaters in Tennessee River, lower French Broad and Holston Rivers, and other potential reintroduction sites. Additional recommendations are incorporated below: • Develop propagation technology and culture techniques for the finerayed pigtoe and other short-term brooding species. o Reintroduce populations through propagation of juveniles in other rivers within the historical range that have potential for viability (e.g., Holston, French Broad, Elk River and the Tennessee River below Wilson Dam). • Conduct mussel and habitat surveys of the Sequatchie River in Tennessee and identify threats to mollusk communities. • Reassess status and viability of currently known populations every five years; specifically, the Little River, TN is a high priority. • Conduct targeted surveys within rivers to develop population estimates and effective population size targets. Continue long-term monitoring in the Clinch, Powell, and Paint Rock rivers, and establish long term mussel monitoring sites in the North Fork Holston and Little rivers. • Coordinate and fund studies to identify potential mussel viruses, diseases, and contaminants which may be associated with die-off events. • Work with TVA, TWRA, and other partners to gather quantitative and qualitative mussel community data and monitor threats in the Elk and Sequatchie rivers, Tennessee. • Evaluate flow release benefits from improved operations at Tims Ford Dam, Elk River, to assess naturally variable seasonal flows, temperatures, and associated DO level increases on freshwater mussels. Continue mussel monitoring and riparian restoration efforts such as buffer initiatives in the Elk River and Copper Creek. (USFWS, 2022)

References

USFWS 2007. Endangered and Threatened Wildlife and Plants

Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee

Final Rule. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461

USFWS 2013. Finerayed Pigtoe Fusconaia cuneolus 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina

USFWS 1984. Fine-rayed Pigtoe Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016).

USFWS 2013. Finerayed Pigtoe Fusconaia cuneolus 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016). USFWS. 2022. Finerayed Pigtoe Fusconaia cuneolus 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Asheville Ecological Services Field Office. 22 pp.

USFWS. 2013. Finerayed Pigtoe Fusconaia cuneolus 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina.

USFWS. 1984. Fine-rayed Pigtoe Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.

USFWS 1984. Fine-rayed Pigtoe Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.

USFWS. 2013. Finerayed Pigtoe (Fusconaia cuneolus)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Asheville Ecological Services Field Office, Asheville, North Carolina.

USFWS. 2022. Finerayed Pigtoe Fusconaia cuneolus 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Asheville Ecological Services Field Office. 22 pp.

SPECIES ACCOUNT: *Fusconaia escambia* (Narrow pigtoe)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/10/2012; Southeast Region (R4) (USFWS, 2016)

Physical Description

The narrow pigtoe (Fusconaia escambia, Clench and Turner 1956) is a small to medium-sized mussel. The subtriangular to squarish shaped shell of the narrow pigtoe reaches about 75 mm (3.0 in.) in length. The shell is moderately thick and is usually reddish brown to black in color. The shell interior is white to salmon in color with iridescence near the posterior margin (Williams and Butler 1994, p. 77; Williams et al. 2008, p. 316). (USFWS 2012)

Taxonomy

The narrow pigtoe was originally described by W. J. Clench and R. D. Turner in 1956. Both molecular (Campbell and Lydeard 2012, p. 28) and morphological (Williams et al. 2008, p. 316) evidence support the distinctiveness of escambia as a species and its assignment to the genus Fusconaia. (USFWS, 2012)

Historical Range

The narrow pigtoe is known from the Escambia River drainage in Alabama and Florida, and the Yellow River drainage in Florida. It inhabited the Escambia River, Conecuh River, Murder Creek, Bottle Creek, Panther Creek, and Yellow River. (USFWS, 2012)

Current Range

Although the Narrow Pigtoe is largely extant throughout its historical range and has populated the two reservoirs, it appears extirpated in some localized areas, especially in the upper reaches of its range. An examination of spatial and temporal changes in Narrow Pigtoe distribution suggested that the population is stable in Florida, but too few surveys have been conducted in Alabama subbasins to fully assess its status throughout its range (USFWS, 2022).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On, October 10, 2012, the U.S. Fish and Wildlife Service designated critical habitat for the narrow pigtoe (Fusconaia escambia), under the Endangered Species Act of 1973, as amended (77 F 61663 61719).-

Critical Habitat Designation

Critical habitat for the narrow pigtoe is designated in GCM1: Lower Escambia River, GCM2: Point A Lake and Gantt Lake Reservoirs, GCM3: Patsaliga Creek, GCM4: Upper Escambia River, and GCM5: Yellow River.

Unit GCM1: Lower Escambia River Drainage, Florida and Alabama. Unit GCM1 encompasses 558 km (347 mi) of the lower Escambia River mainstem and 12 tributary streams in Escambia and Santa Rosa Counties, FL, and Escambia, Covington, Conecuh, and Butler Counties, AL. The unit consists of the main channel of the EscambiaConecuh River from the confluence of Spanish Mill Creek, Escambia and Santa Rosa counties, FL, upstream 204 km (127 mi) to the Point A Lake dam, Covington County, AL; Murder Creek from its confluence with the Conecuh River, Escambia County, AL, upstream 62 km (38 mi) to the confluence of Cane Creek, Conecuh County, AL; Burnt Corn Creek from its confluence with Murder Creek, Escambia County, AL, upstream 59 km (37 mi) to County Road 20, Conecuh County, AL; Jordan Creek from its confluence with Murder Creek, upstream 5.5 km (3.5 mi) to Interstate 65, Conecuh County, AL; Mill Creek from its confluence with Murder Creek upstream 2.5 km (1.5 mi) to the confluence of Sandy Creek, Conecuh County, AL; Sandy Creek from its confluence with Mill Creek upstream 5.5 km (3.5 mi) to County Road 29, Conecuh County, AL; Sepulga River from its confluence with the Conecuh River upstream 69 km (43 mi) to the confluence of Persimmon Creek, Conecuh County, AL; Bottle Creek from its confluence with the Sepulga River upstream 5.5 km (3.5 mi) to County Road 42, Conecuh County, AL; Persimmon Creek from its confluence with the Sepulga River, Conecuh County, upstream 36 km (22 mi) to the confluence of Mashy Creek, Butler County, AL; Panther Creek from its confluence with Persimmon Creek upstream 11 km (7 mi) to State Route 106, Butler County, AL; Pigeon Creek from its confluence with the Sepulga River, Conecuh and Covington Counties, upstream 89 km (55 mi) to the confluence of Three Run Creek, Butler County, AL; and Three Run Creek from its confluence with Pigeon Creek upstream 9 km (5.5 mi) to the confluence of Spring Creek, Butler County, AL. Unit GCM1 is within the geographical area occupied at the time of listing (2012) for the round ebonyshell, southern kidneyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Escambia River system is within the species' historical range, and we consider it essential to the southern kidneyshell's conservation due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. The unit currently supports populations of round ebonyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, cooccur with these five species. A diverse fish fauna, including potential fish host(s) for the fuzzy pigtoe, are known from the Escambia River drainage, indicating the potential presence of PCE 5. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to two upstream impoundments. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM2: Point A Lake and Gantt Lake Reservoirs, Alabama. Unit GCM2 encompasses 21 km (13 mi) of the Point A Lake and Gantt Lake reservoir system in Covington County, AL. Both lakes are impoundments on the Conecuh River main channel in the Escambia River drainage. The unit extends from Point A Lake dam, Covington County upstream 21 km (13 mi) to the Covington-Crenshaw County line in Alabama. Unit GCM2 is within the geographical area occupied at the time of listing (2012) for the narrow pigtoe. As mentioned in discussion of essential physical or biological features for the narrow pigtoe, we attribute its occurrence in these two impoundments to the small size of the reservoirs and to the operational regime of the dams. This allows for water movement through the system, and prevents silt accumulation in some areas. The largest narrow pigtoe population occurs in the middle reach of Gantt Lake, where the reservoir narrows and becomes somewhat riverine. Although the natural state of the river's hydrological flow regime is modified, it does retain the presence of the physical or biological features necessary to maintain the benthic habitats where the species are found. The persistence of the narrow pigtoe within these reservoirs indicates the presence of an appropriate fish host. Although its fish host(s) is unknown, other mussels of the genus Fusconaia are known to use cyprinid minnows, fish that occupy a variety of habitats including large, flowing rivers, and lakes and reservoirs (Mettee et al. 1996, p. 128). The unit currently supports narrow pigtoe populations, indicating the elements of essential physical or biological features, and contains PCEs 1, 3, 4, and 5. We consider the habitat in this unit essential to the conservation of the narrow pigtoe as it possesses the largest known population. The fuzzy pigtoe is known historically from this stretch of the Conecuh River (one specimen was collected in 1915). However, the collection was made prior to construction of the reservoirs in 1923, and it is not presently known to occur in this now-impounded section of the river. Threats to the narrow pigtoe and its habitat that may require special management of the physical or biological features include the potential of significant changes in water levels due to periodic drawdowns of the reservoirs for maintenance to the dams. Within the two reservoirs, mussels occur in shallow areas near the shore, where they are susceptible to exposure when water levels are lowered. A drawdown of Point A Lake in 2005, and Gantt Lake in 2006, exposed and killed a substantial number of mussels (Johnson 2006 in litt.). During the Gantt drawdown, 142 individuals of narrow pigtoe were relocated after being stranded in dewatered areas near the shoreline (Garner 2009 pers. comm.; Pursifull 2006, pers. obs.).

Unit GCM5: Yellow River Drainage, Florida and Alabama. Unit GCM5 encompasses 247 km (153 mi) of the Yellow River mainstem, the Shoal River mainstem, and three tributary streams in Santa Rosa, Okaloosa, and Walton Counties, FL, and Covington County, AL. The unit consists of the Yellow River from the confluence of Weaver River (a tributary located 0.9 km (0.6 mi), downstream of State Route 87), Santa Rosa County, FL, upstream 157 km (97 mi) to County Road 42, Covington County, AL; the Shoal River from its confluence with the Yellow River, Okaloosa County, FL, upstream 51 km (32 mi) to the confluence of Mossy Head Branch, Walton County, FL; Pond Creek from its confluence with Shoal River, Okaloosa County, FL, upstream 24 km (15 mi) to the confluence of Fleming Creek, Walton County, FL; and Five Runs Creek from its confluence with the Yellow River upstream 15 km (9.5 mi) to County Road 31, Covington County, AL. Unit GCM5 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell was known from the Yellow River drainage; however, its occurrence in the basin is based on the collection of one specimen in 1919 from Hollis Creek in Alabama. We believe this single, historical record is not sufficient to consider this unit as essential to the conservation of the southern kidneyshell. Therefore, we are not designating Unit GCM5 as critical habitat for the southern kidneyshell at this time. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna are known from the Yellow River drainage, indicating the potential presence of PCE 5.

Primary Constituent Elements/Physical or Biological Features

Within critical habitat areas, the primary constituent elements of the physical or biological features essential to the conservation of the narrow pigtoe consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to this species and its habitat are pervasive and common in all of the units that are designated as critical habitat. These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas designated as critical habitat are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species. (NatureServe 2015)

Reproduction Narrative

Adult: It is believed to be a short-term brooder, with females gravid during spring and summer. The host fish for the narrow pigtoe is currently unknown (Williams et al. 2008, p. 317) however, other species of the same genera are known to parasitize cyprinids (minnows), centrarchids (sunfish), and percids (darters) (Haag and Warren 1997, pp. 580–581, 583; Keller and Ruessler 1997, p. 405; O'Brien and Brim Box 1999, p. 134; Haag et al. 1999, p. 150; Haag and Warren 2003, pp. 81–82; Luo 1993, p. 16). (USFWS 2012). Studies by FWC of Narrow Pigtoe early life history have provided new information. Field examination of 550 individuals from the Escambia River in Florida found 103 gravid females from early March to late October, with the peak months of gravidity in May to July (Holcomb et al. 2020). Laboratory host trials identified nine fish species from five genera as hosts for Narrow Pigtoe larvae, with Blacktail Shiner (Cyprinella venusta) and Weed Shiner (Notropis texanus) consistently producing the greatest number of viable juvenile mussels (USFWS, 2022).

Geographic or Habitat Restraints or Barriers

Adult: Dams (see dispersal/migration narrative)

Spatial Arrangements of the Population

Adult: Linear (USFWS 2012)

Environmental Specificity

Adult: Narrow to moderate (NatureServe 2012)

Tolerance Ranges/Thresholds

Adult: Low to moderate (see population narrative)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: It is found in medium creeks to medium rivers, in stable substrates of sand, sand and gravel, or silty sand, with slow to moderate current. The species is somewhat unusual in that it tolerates a small reservoir environment (Williams 2009 pers. comm.). The habitat is linear in nature. Primary constituent elements include (1) Geomorphically stable stream and river channels and banks (2) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae (3) A hydrologic flow regime necessary to maintain benthic habitats and connectivity of rivers with the floodplain (4) Water quality, including temperature (not greater than 32 oC), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 mg/L). (USFWS 2012) The environmental specificity of this species is narrow to moderate (see population narrative) (NatureServe 2015)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

<u>Adult:</u> Non-migratory (NatureServe 2015)

Dispersal

<u>Adult:</u> Low - moderate (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

<u>Adult:</u> Host fish (NatureServe 2015)

Dispersal/Migration Narrative

<u>Adult:</u> Adults of this species are essentially sessile. About the only voluntary movement the make is to burrow deeper into the substrate. Except for occasional passive downstream movement when adults are disrupted from the substrate during floods, dispersal occurs while the glochidia are encysted on their host (probably a fish). (NatureServe 2015) By blocking fish movement, the dams may prevent gene exchange between upstream and downstream mussel populations. (USFWS 2012)

Population Information and Trends

Population Trends:

Not available

Number of Populations:

1 - 20 (NatureServe 2015)

Population Size:

2,500 - 10,000 (NatureServe 2015)

Additional Population-level Information:

Narrow Pigtoe records are known from the Escambia River basin in Alabama and Florida and the Yellow River basin in Florida (Fig. 7). Overall, the species maintains low abundance at most locations and appears extirpated from multiple historical locations. Narrow Pigtoe current (2000– 2021) occurrences are discussed below and summarized by subbasin in Appendix A. Escambia River Basin In the Upper Conecuh subbasin, approximately 4,115 individuals have been observed since 2000. New information is available regarding Narrow Pigtoe populations in Point A and Gantt lakes because of salvage efforts during full drawdowns of the reservoirs in 2017 and 2019. The reservoirs support suitable Narrow Pigtoe habitat in some submerged areas, and reproducing populations occur in both reservoirs. PowerSouth Energy Cooperative and resource agencies coordinated large-scale salvage events to move mussels from dewatered areas to the unaffected reservoir. In September 2017, 241 stranded individuals were collected in Point A Lake and relocated to suitable habitat in Gantt Lake. In the larger Gantt Lake reservoir, significant survey effort (approximately 2,000 survey hours over 5 days) resulted in the relocation of 3,817 individuals to Point A in September 2019. The maintenance drawdowns last for several weeks and many Narrow Pigtoe (especially small individuals) likely go undetected and perish due to extended emersion or predation. Full drawdowns occur about every 10 years and previously occurred in 2005 and 2006, demonstrating that the species can withstand these periodic disturbance events and maintain localized populations in the reservoirs. Although relatively abundant and reproducing, the reservoir populations are isolated and spatially limited. Outside of the reservoirs, the species occurs in one mainstem location upstream of Gantt Lake, however, too few surveys have been conducted in this reach to accurately assess its status in this portion of its historical range. In the Patsiliga and Sepulga subbasins, a total of three live individuals have been observed since 2000. The Patsiliga population is isolated by the dams. Too few surveys have been conducted in these subbasins to fully assess its status in this portion of its range. Available survey data indicates it persists in very low abundance and is declining in these subbasins. The species appears to be maintaining populations in the Lower Conecuh subbasin, where 93 live individuals were observed since 2000. In the Escambia subbasin, considerable recent sampling effort detected 920 live Narrow Pigtoe individuals in the Escambia River and Pine Barren Creek. The species is locally extirpated around the state line but is maintaining populations elsewhere in the Escambia River. Yellow River basin All observations are from the Yellow River in Florida, where 49 individuals have been observed since 2000. Only three historical Narrow Pigtoe observations exist for the basin, making it difficult to assess trends. Based on available data, it may be extirpated in the upper-most extent of its range, near the State Road 2 crossing. (USFWS, 2022).

Population Narrative:

McGregor (2004, p. 55) considered the narrow pigtoe vulnerable to extinction because of its limited distribution, rarity, and susceptibility to habitat degradation. It is unknown if this species is currently experiencing a loss of genetic diversity. (USFWS 2012) There are 1 - 20 occurrences of this species, with 1 - 12 having good viability/integrity, and a population size of 2,500 - 10,000 individuals. This species is moderately vulnerable, as freshwater mussels are inherently vulnerable to threats from siltation, pollution, eutrophication, channelization, impoundment, collection, drought and water withdrawal, competition from invasive non-native mussels, and changes to larval host fish populations. However, this species may be somewhat tolerant to sedimentation. (NatureServe 2015)

Threats and Stressors

Stressor: Pollution (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Nonpoint-source pollution from land surface runoff originates from virtually all land use activities and includes sediments, fertilizer, herbicide and pesticide residues; animal wastes; septic tank leakage and gray water discharge; and oils and greases. Current activities and land uses that can negatively affect populations of these eight mussels include unpaved road crossings, improper silviculture and agriculture practices, highway construction, housing developments, pipeline crossings, and cattle grazing. Land surface runoff also contributes nutrients (for example, nitrogen and phosphorus from fertilizers, sewage, and animal manure) to rivers and streams, causing them to become eutrophic. Excessive nutrient input stimulates excessive plant growth (algae, periphyton attached algae, and nuisance plants). This enhanced plant growth can cause dense mats of filamentous algae that can expose juvenile mussels to entrainment or predation and be detrimental to the survival of juvenile mussels (Hartfield and Hartfield 1996, p. 373). Excessive plant growth can also reduce dissolved oxygen in the water when dead plant material decomposes. Because of their sedentary characteristics, mussels are extremely vulnerable to toxic effluents (Sheehan et al. 1989, pp. 139–140; Goudreau et al. 1993, pp. 216–227; Newton 2003, p. 2543). (USFWS 2012)

Stressor: Sedimentation (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Sedimentation is one of the most significant pollution problems for aquatic organisms (Williams and Butler 1994, p. 55), and has been determined to be a major factor in mussel declines (Ellis 1936, pp. 39–40). Impacts resulting from sediments have been noted for many components of aquatic communities. For example, sediments have been shown to abrade or suffocate periphyton (organisms attached to underwater surfaces); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters 1995, pp. 173– 175). Heavy sediment loads can destroy mussel habitat, resulting in a corresponding shift in mussel fauna (Brim Box and Mossa 1999, p. 100). Excessive sedimentation can lead to rapid changes in stream channel position, channel shape, and bed elevation (Brim Box and Mossa 1999, p. 102). Sedimentation has also been shown to impair the filter feeding ability of mussels. When in high silt environments, mussels may keep their valves closed more often, resulting in reduced feeding activity (Ellis 1936, p. 30), and high amounts of suspended sediments can dilute their food source (Dennis 1984, p. 212). Increased turbidity from suspended sediment can reduce or eliminate juvenile mussel recruitment (Negus 1966, p. 525; Brim Box and Mossa 1999, pp. 101–102). Many mussel species use visual cues to attract host fishes; such a reproductive strategy depends on clear water. Potential sediment sources within a watershed include virtually any activity that disturbs the land surface. Current sources of sand, silt, and other sediment accumulation in south-central Alabama and western Florida stream channels include unpaved road runoff, agricultural lands, timber harvest, livestock grazing, and construction and other development activities (Williams and Butler 1994, p. 55; Bennett 2002, p. 5 and references therein; Hoehn 1998, pp. 46–47 and references therein). (USFWS 2012)

Stressor: Channel instability (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Mussels require stable stream and river habitats and activities that cause channel instability can negatively impact their populations. Activities such sand and gravel mining, the removal of large woody material, off-road vehicles use, and land use changes are known to cause channel destabilization. Activities that destabilize stream beds and channels can result in drastic alterations to stream geomorphology and consequently to the stream's ecosystem. Instream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, p. 10; Hartfield 1993, pp. 138–139). Poorly located or inadequately designed mines in the flood plain can have similar effects and result in alterations to streams channels (Mossa and Coley, 2004, p. 2). Land use activities such as land clearing and development can cause channel instability by accelerating storm water runoff into streams. (USFWS 2012)

Stressor: Impoundments (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The damming of rivers has been a major factor contributing to the demise of freshwater mussels (Bogan 1993, p. 604). Dams eliminate or reduce river flow within impounded

areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, affect normal flood patterns, and block upstream and downstream movement of mussels and their host fishes (Bogan 1993, p. 604; Vaughn and Taylor 1999, pp. 915–917; Watters 1999, pp. 261–264; McAllister et al. 2000, p. iii; Marcinek et al. 2005, pp. 20–21). Downstream of dams, mollusk declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels, water temperatures, and changes in resident fish assemblages (Williams et al. 1993, p. 7; Neves et al. 1997, pp. 63–64; Watters 1999, pp. 261– 264; Marcinek et al. 2005, pp. 20–21). (USFWS 2012)

Stressor: Stochastic events (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may contribute to the further decline of mussel populations suffering the effects of other threats. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin et al. 2002, p. 6074; Golladay et al. 2004, p. 504; Cook et al. 2004, p. 1015). Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in stream temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions. (USFWS 2012)

Stressor: Small, isolated populations (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153). (USFWS 2012)

Stressor: Nonindigenous species (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The Asian clam (Corbicula fluminea) has been introduced to the drainages and may be adversely affecting these eight mussels through direct competition for space and resources. Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles, and may actively disturb sediments, reducing habitable space for juvenile native mussels, or displacing them downstream (Strayer 1999, p. 82; Yeager et al. 2000, pp. 255–256). The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations. Biologists working in the Florida portions of these drainages have observed a correlation between the increase in flathead catfish numbers and a decrease in numbers of other native fish species, particularly of bullhead catfish (Ameiurus sp.) and redbreast sunfish (Lepomis auritus) (Strickland 2010 pers. comm.). (USFWS 2012)

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Maintain high water and benthic habitat (substrate) qualities, as well as adequate flow regimes, throughout all occupied river systems. This may be partially accomplished via establishment of buffers and streamside management zones for all agricultural, silvicultural, mining, and developmental activities; protection of floodplain forests and adjoining upland habitat is paramount. (NatureServe 2015)
- Prevent damming, dredging, and pollution throughout drainages, but especially near recorded sites. Remove existing dams, but with great care to limit downstream sedimentation. (NatureServe 2015)
- Limit withdrawal of surface and subterranean waters as necessary to maintain normal stream flows, especially during drought. (NatureServe 2015)
- Prevent or limit establishment of invasive species (including zebra mussel, Dreissena polymorpha) to the extent possible. (NatureServe 2015)
- Where appropriate, protect populations through acquisitions and easements over streamside lands by working with government agencies and conservation organizations. (NatureServe 2015)

References

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 FR 61663 - 61719 (October 10, 2012).

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016). USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016).

SPECIES ACCOUNT: *Fusconaia masoni* (Atlantic pigtoe)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The Atlantic Pigtoe is a small freshwater mussel with a sub-rhomboidal shaped shell. Although larger specimens exist, the Atlantic Pigtoe rarely exceeds 50mm (2 inches) in length (Wisniewski 2008, p.1; Figure 2-1). Except in headwater stream reaches, where specimens may be elongated, this species is tall relative to its length (Alderman and Alderman 2014, p.5). Valves are compressed, the hinge ligament is relatively short and prominent, and the umbo is positioned slightly anterior of the middle of valve and is elevated above the hingeline (Fuller 1973, p.106; Wisniewski 2008, p.1). The posterior ridge is angular and very distinct. The periostracum is yellow to dark brown, and has been described as clothlike or parchmentlike (Fuller 1973, p.107), and young individuals may have greenish rays across the entire shell surface. When collected fresh, the nacre in the anterior half of the shell tends to be salmon colored, while nacre in the posterior half tends to be more iridescent (Fuller 1973, p.107; Alderman and Alderman 2014, p.5). The shell has full dentition with two pseudocardinals in each valve (although the anterior one in right valve is vestigial) and well developed lateral teeth (Fuller 1973, p.107). In addition to simple papillae, branched and arborescent papillae are often seen on the incurrent aperture (Alderman and Alderman 2014, p.5). Salmon colored demibranchs in females is often seen during the spawning season. When fully gravid, females use all 4 demibranchs to brood glochidia (Fuller 1973, p. 108) (USFWS, 2019).

Taxonomy

The currently accepted classification is (Integrated Taxonomic Information System 2016): Phylum: Mollusca Class: Bivalvia Order: Unionoida Family: Unionidae Subfamily: Ambleminae Genus: Fusconaia Species: Fusconaia masoni (USFWS, 2019).

Historical Range

The Atlantic Pigtoe has been documented in all major river basins in the Atlantic coastal drainages from the James River Basin in Virginia south to the Altamaha River Basin in Georgia. Johnston (1970, p.302) indicated the southernmost records were from the Ogeechee River Basin, however, recent curation of the H.D. Athearn collection uncovered valid specimens from the Altamaha River (NCSM 54068). The Atlantic Pigtoe has been documented from multiple physiographic provinces, from the foothills of the Appalachian Mountains through the Piedmont and into the Coastal Plain, in streams ranging in size from < 1 m wide up to some of the largest Atlantic Slope rivers within the species' range (USFWS, 2019).

Current Range

GA, NC, VA; For the purposes of this assessment, populations were delineated using the twelve river basins that Atlantic Pigtoe mussels have historically occupied. This includes the James, Chowan, Roanoke, Tar, Neuse, Cape Fear, Pee Dee, Catawba, Edisto, Savannah, Ogeechee, and Altamaha River basins, and from here forward, we will use these terms to refer to populations (e.g., Tar population). Of twelve historical populations, seven populations have observations in the last 10 years, though the majority of occurrences were limited to a single location within the river basin. The Atlantic Pigtoe is presumed extirpated from the southern portion of the range.

Because the river basin level is at a very coarse scale, populations were further delineated using management units (MUs). MUs were defined as one or more HUC10 watersheds that species experts identified as most appropriate for assessing population-level resiliency (see Section 3.3; Appendix A). Range-wide species occurrence data were used to create “occurrence heat maps” that discretize HUC10 watersheds into 5-year increments based on the date of observed occurrences (see GADNR 2016a; Appendix B). These heat maps display recent observed occurrences using various shades of red, while older observed occurrences are displayed in various shades of blue (e.g., Figure 3-2). Documented species occurrences are included to show distribution within HUC10s. Throughout this section, heat maps are used to characterize the historic and current distribution of Atlantic Pigtoe among MUs for each of twelve populations (USFWS, 2019).

Critical Habitat Designated

Yes; 12/16/2021.

Legal Description

: We, the U.S. Fish and Wildlife Service (Service), list the Atlantic pigtoe, (Fusconaia masoni), a freshwater mussel species from Virginia and North Carolina, as a threatened species with a rule issued under section 4(d) of the Endangered Species Act of 1973 (Act), as amended. We also designate critical habitat for the species under the Act. In total, approximately 563 river miles (906 river kilometers) fall within 17 units of critical habitat in Bath, Botetourt, Brunswick, Craig, Dinwiddie, Greensville, Halifax, Lunenburg, Mecklenburg, Nottoway, Pittsylvania, and Sussex Counties, Virginia, and in Durham, Edgecombe, Franklin, Granville, Halifax, Johnston, Montgomery, Nash, Orange, Person, Pitt, Randolph, Rockingham, Vance, Wake, Warren, and Wilson Counties, North Carolina. This rule extends the Act’s protections to the species and its designated critical habitat. (USFWS, 2021)

Critical Habitat Designation

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Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of Atlantic pigtoe consist of the following components: (i) Suitable substrates and connected instream habitats, characterized by geomorphically stable stream channels and banks (i.e., channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with habitats that support a diversity of freshwater mussel and native fish (such as stable riffle-run-pool habitats that provide flow refuges consisting of silt-free gravel and coarse sand substrates). (ii) Adequate flows, or a hydrologic flow regime (which includes the severity, frequency, duration, and seasonality of discharge over time), necessary to maintain benthic habitats where the species is found and to maintain connectivity of streams with the floodplain, allowing the exchange of nutrients and sediment for maintenance of the mussel’s and fish hosts’ habitat, food availability, spawning habitat for native fishes, and the ability for newly transformed juveniles to settle and become established in their habitats. (iii)

Water and sediment quality (including, but not limited to, conductivity, hardness, turbidity, temperature, pH, ammonia, heavy metals, and chemical constituents) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages. (iv) The presence and abundance of fish hosts necessary for recruitment of the Atlantic pigtoe. (3) Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on December 16, 2021.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. Special management considerations or protection may be required of the Federal action agency to eliminate, or to reduce to negligible levels, the threats affecting the physical and biological features of each unit. The features essential to the conservation of the Atlantic pigtoe may require special management considerations or protections to reduce the following threats: (1) Urbanization of the landscape, including (but not limited to) land conversion for urban and commercial use, infrastructure (roads, bridges, utilities), and urban water uses (water supply reservoirs, wastewater treatment, etc.); (2) nutrient pollution from agricultural activities that impact water quantity and quality; (3) significant alteration of water quality; (4) incompatible forest management or silviculture activities that remove large areas of forested wetlands or riparian systems; (5) culvert and pipe installation that creates barriers to movement; (6) impacts from invasive species; (7) changes and shifts in seasonal precipitation patterns as a result of climate change; and (8) other watershed and floodplain disturbances that release sediments or nutrients into the water. Management activities that could ameliorate these threats include, but are not limited to: Use of BMPs designed to reduce sedimentation, erosion, and bank side destruction; protection of riparian corridors and maintenance of sufficient canopy cover along banks; moderation of surface and ground water withdrawals to maintain natural flow regimes; increased use of stormwater management and reduction of stormwater flows into the systems; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. (USFWS, 2021)

Life History

Reproduction Narrative

Adult: The Atlantic Pigtoe is a short-term, tachytictic breeder, meaning spawning takes place in the early spring with release of semi-buoyant white to pink-colored conglutinates in the late spring to early summer (C.Eads (NCSU) email to S.McRae (USFWS) on 1/13/2016; Alderman and Alderman 2014, p.9; Figure 2-3). The conglutinates are tubular, and the color varies from white to pink to red depending on the percentage of fertilization, with less fertilization being more red (unfertilized eggs are red) (C.Eads (NCSU) email to S.McRae (USFWS) on 1/13/2016). Like other species in the Pleurobemini tribe, the Atlantic Pigtoe targets drift-feeding minnow species by releasing pelagic conglutinates (Haag 2012, p.163), a highly targeted strategy that decreases encounters with incompatible fish species. Following release from the female mussel, the semi-buoyant conglutinates float and occupy the middle and upper water column where they are targeted by sight-feeding minnows (as referenced in Wolf 2012, p.33). Time period for glochidia to complete metamorphosis varies between 8-19 days at 21-22ºC, and depends on the host fish (Eads and Levine 2011, p.11). Atlantic Pigtoe demonstrates an “equilibrium life history strategy”, which means it is a slowgrowing and long-lived species with low fecundity (Haag 2012, p.211; Alderman and Alderman 2014, p.9). As seen in many organisms, this mussel’s growth is rapid during the first few years of life but slows with increasing age, as resources are likely diverted to reproduction. Patterns of age structure in healthy Atlantic Pigtoe populations are available for the Nottoway River and Swift Creek (Tar) populations. Shell thin-sectioning conducted by Wolf (2012, p.27- 29; Figure 2-4) yielded a population with multiple age classes ranging from 1 to 58 years (although the 58 year old individual was likely an outlier and when removed the age range is 1- 33 years). Similarly, a 1991 survey of muskrat middens in Swift Creek (Tar) revealed multiple size classes, ranging from 16mm to 63mm (approximately ages 1 to 30+ years) (Alderman and Alderman 2014, p.31; Figure 2-5). In captivity in a hatchery/pond settting, age to sexual maturity is approximately 3 years (C.Eads (NCSU), pers. comm.). Fecundity is uniformly low in most species that have an equilibrium strategy (Haag 2012, p.211), and species like Atlantic Pigtoe rely on a consistent, low-level of reproductive success to maintain populations. This strategy can allow populations to reach high densities over time in stable habitats, but it also makes them susceptible to habitat disturbances (Wolf 2012, p.33). Thus, loss of a small proportion of the Atlantic Pigtoe population when population levels are already low, or a bad recruitment year, can have a dramatic effect on reproductive success (Wolf 2012, p.33). (USFWS, 2019).

Habitat Narrative

Adult: The Atlantic Pigtoe is dependent on clean, moderate flowing water with high dissolved oxygen content in creek and riverine environments. Historically, the best populations existed in creeks and rivers with excellent water quality, where stream flows were sufficient to maintain clean, silt-free substrates (Alderman and Alderman 2014, p.8). Because this species prefers more pristine conditions, it typically occurs in headwaters and rural watersheds. It is associated with gravel and coarse sand substrates at the downstream edge of riffles, and less commonly occurs in cobble, silt, or sand detritus mixtures (Bogan and Alderman 2008, p.30). Most freshwater mussels, including the Atlantic Pigtoe, are found in aggregations (mussel beds) that vary in size and are often separated by stream reaches in which mussels are absent or rare (Vaughn 2012, p. 983). Genetic exchange occurs between and among mussel beds via sperm drift, host fish movement, and movement of mussels during high flow events. Theoretically, prior to anthropogenic influence, it is likely that Atlantic Pigtoe mussel beds were distributed contiguously in suitable habitats throughout its known range. As we discuss in more detail below, the contemporary distribution of Atlantic Pigtoe is patchy, resulting in largely isolated populations and, in turn, potentially limited genetic exchange (USFWS, 2019).

Dispersal/Migration

Population Information and Trends

Resiliency:

Resiliency, assessed at the population level, describes the ability of a population to withstand stochastic disturbance events. A species needs multiple resilient populations distributed across its range to persist into the future and avoid extinction. A number of factors, including (but not limited to) water quality, water quantity, habitat connectivity, and instream substrate, may influence whether Atlantic Pigtoe populations will occupy available habitat. As we considered the future viability of the species, more populations with high resiliency distributed across the known range of the species can be associated with higher species viability. As a species, the

Atlantic Pigtoe has limited resiliency, with many of the populations in low or presumed extirpated condition (USFWS, 2019).

Representation:

Representation characterizes a species' adaptive potential by assessing geographic, genetic, ecological, and niche variability. The Atlantic Pigtoe has exhibited historical variability in the physiographic regions it inhabited, as well as the size and range of the river systems it inhabited. The species has been documented from small streams to large rivers in multiple physiographic provinces, from the foothills of the Appalachian Mountains through the Piedmont and into the Coastal Plain. Much of the representation of the Atlantic Pigtoe has been lost; physiographic variability has been lost with 76% loss in the Coastal Plain, 67% loss in the Mountains, and 48% loss in the Piedmont, and the remaining occurrences are represented by very few individuals in very few locations (USFWS, 2019).

Redundancy:

Redundancy describes the ability of the species to withstand catastrophic disturbance events; for the Atlantic Pigtoe, we considered whether the distribution of resilient MUs within populations was sufficient for minimizing the potential loss of the species from such an event. The Atlantic Pigtoe historically ranged from the James River Basin in Virginia to the Altamaha River Basin in Georgia, but both the number and distribution of mussel populations occupying that historical range has declined over the past 60 years (USFWS, 2019).

Threats and Stressors

Stressor: Development
Exposure:
Response:
Consequence:
Narrative: Development refers to urbanization of the landscape, including (but not limited to) land conversion for urban and commercial use, infrastructure (roads, bridges, utilities), and urban water uses (water supply reservoirs, wastewater treatment, etc.). The effects of urbanization may include alterations to water quality, water quantity, and habitat (both in stream and streamside) (Ren et al. 2003, p. 649; Wilson 2015, p. 424). These alterations adversely affect both Atlantic pigtoe adults, which require clear, flowing water with a temperature less than 35 degrees Celsius (°C) (95 degrees Fahrenheit (°F)) and a dissolved oxygen greater than 3 milligrams per liter (mg/ L), and juveniles, which require very specific interstitial chemistry to complete that life stage: Low salinity (similar to 0.9 parts per thousand (ppt)), low ammonia (similar to 0.7 mg/L), low levels of copper and other contaminants, and dissolved oxygen greater than 1.3 mg/L (USFWS, 2021).

Stressor: Systemic Changes
Exposure:
Response:
Consequence:
Narrative: Climate Change: Aquatic systems are encountering changes and shifts in seasonal patterns of precipitation and runoff as a result of climate change. While mussels evolved in habitats that experience seasonal fluctuations in discharge, global weather patterns can have an impact on the normal regimes (e.g., El Nin˜ o or La Nin˜ a). Both excessively high (i.e., floods and

storms) and excessively low (i.e., droughts) flows can adversely affect the species (USFWS, 2021).

Stressor: Invasive Species
Exposure:
Response:
Consequence:
Narrative: Nonnative species are invading aquatic communities and altering biodiversity by competing with native species for food, light, or breeding and nesting areas in many areas across the range of the Atlantic pigtoe (USFWS, 2021).

Stressor: Dams and Barriers
Exposure:
Response:
Consequence:
Narrative: Extinction and extirpation of North American freshwater mussels can be traced to impoundment and inundation of riffle habitats in all major river basins of the central and eastern United States. Upstream of dams, the change from flowing to impounded waters, increased depths, increased buildup of sediments, decreased dissolved oxygen, and the drastic alteration in resident fish populations can threaten the survival of mussels and their overall reproductive success. Downstream of dams, fluctuations in flow regimes, minimal releases and scouring flows, seasonal dissolved oxygen depletion, reduced or increased water temperatures, and changes in fish assemblages can also threaten the survival and reproduction of many mussel species (USFWS, 2021).

Recovery

Reclassification Criteria:
Recovery Priority Number: 11C

Conservation Measures and Best Management Practices:

- Permits to fill wetlands and fill, culvert, bridge or re-align streams or water features are issued by the U.S. Army Corps of Engineers under Nationwide, Regional General Permits or Individual Permits. ● Nationwide Permits are for “minor” impacts to streams and wetlands, and do not require an intense review process. These impacts usually include stream impacts under 150 feet, and wetland fill projects up to 0.50 acres. Mitigation is usually provided for the same type of wetland or stream impacted, and is usually at a 2:1 ratio to offset losses and make the “no net loss” closer to reality. ● Regional General Permits are for various specific types of impacts that are common to a particular region; these permits will vary based on location in a certain region/state. ● Individual permits are for the larger, higher impact and more complex projects. These require a complex permit process with multi-agency input and involvement. Impacts in these types of permits are reviewed individually and the compensatory mitigation chosen may vary depending on project and types of impacts. (USFWS, 2021)

References

U.S. Fish and Wildlife Service. 2019. Species status assessment report for the Atlantic Pigtoe (Fusconaia masoni). Version 1.3. April, 2019. Atlanta, GA. U.S. Fish and Wildlife Service. 2021. Endangered and Threatened Wildlife and Plants

Threatened Species Status With Section 4(d) Rule for Atlantic Pigtoe and Designation of Critical Habitat. Final Rule. FR Vol. 86, No. 218. Pages 64000-64053.

U.S. Fish and Wildlife Service. 2021. Endangered and Threatened Wildlife and Plants

U.S. Fish and Wildlife Service. 2019. Species status assessment report for the Atlantic Pigtoe (Fusconaia masoni). Version 1.3. April, 2019. Atlanta, GA.

USFWS. 2021a. Species status assessment report for the Atlantic Pigtoe (Fusconaia masoni). Version 1.4. June, 2021. Atlanta, GA.

SPECIES ACCOUNT: *Fusconaia mitchelli* (False spike)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The false spike is a medium-sized freshwater mussel (to 132 mm) with a yellow-green to brown, to black, elongate shell, sometimes with greenish ray (USFWS, 2022)

Taxonomy

The false spike was originally described as the species Unio mitchelli by Charles T. Simpson in 1895 from the Guadalupe River in Victoria County, Texas (Dall 1896, pp. 5-6). A similar species, Unio iheringi was described as a new species by Berlin H. Wright in 1898 from the San Saba River (a tributary of the Colorado) in Menard County, Texas (Wright 1898, p. 93). This taxon was recognized as a form of Unio mitchelli var. iheringi by Simpson in 1914 (pp. 622-3). Strecker (1931) synonymized Unio mitchelli (from the Guadalupe River) and Unio iheringii (from the San Saba River) and treated false spike as Elliptio tamaulipasensis 2 and noted it “a variable species with long and short, compressed and inflated forms living in the same stream” and found in the Brazos, Colorado, and Guadalupe systems from locations including the Leon River in Bell and Coryell Counties, Guadalupe River in Comal, Kendall, Kerr and Victoria Counties, Llano River in Mason County, and the San Saba River in Menard County (USFWS, 2022).

Historical Range

The false spike was previously believed to occur in the Brazos, Colorado, and Guadalupe drainages in Central Texas (Howells 2010, p. 4; Randklev et al. 2017c, p. 12; Figure 3.1). However, following genetic analyses by Smith et al. (2020, entire), populations of the false spike from the Guadalupe River basin are now considered a separate and distinct species from the populations in the Colorado and Brazos River basins, which are now known as the Balcones spike (Fusconaia iheringi). The false spike was, in the past, thought to have historically occurred in the Rio Grande based on fossil and subfossil shells (Howells 2010, p. 4), but those specimens have now been attributed to Sphenonaias taumilapana Conrad 1855 (no common name; Randklev et al. 2017c, p. 12; Graf and Cummings 2007, p. 309). False spike was once considered common wherever it was found; however, beginning in the early 1970s, the species began to be regarded as rare throughout its range, based on collection information (Strecker 1931, pp. 18-19; Randklev et al. 2017c, p. 13). Williams et al. (1993, p.14) noted that false spike was rare throughout its range and ranked it threatened, and Nature Serve (2016, p.1) ranked the species as critically imperiled. Howells (2010, p. 4) indicated that no living populations were known in the previous 30 years. However, in 2011, the discovery of 7 live false spike in the Guadalupe River, near Gonzales, Texas, was the first report of living individuals in nearly four decades (USFWS, 2022).

Current Range

False spike was suspected of being extinct until living individuals were discovered in the Guadalupe River basin in 2011-2013 (Howells 2014, p. 85). Randklev et al. (2017, p.11) surveyed 13 sites in the Guadalupe River drainage in DeWitt and Victoria counties and found 1 live false spike individual near Cuero, TX (Figure 5.1). The currently occupied stream length of the false spike population is 102.6 stream miles, which equates to approximately 20% of the presumed

512 stream mile historical range for the species. This approximate range reduction assumes the species continuously occupied its entire historical range, which is unlikely given the species' specialized habitat preferences (USFWS, 2022).

Critical Habitat Designated

Yes;

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli), and threatened species status for the Texas fawnsfoot (Truncilla macrodon), seven species of freshwater mussels from central Texas. We also issue a rule under section 4(d) of the Act for the Texas fawnsfoot that provides measures that are necessary and advisable to provide for the conservation of the Texas fawnsfoot. In addition, we designate critical habitat for all seven species. In total, approximately 1,577.5 river miles (2,538.7 river kilometers) in Blanco, Brown, Caldwell, Coleman, Comal, Concho, DeWitt, Gillespie, Gonzales, Guadalupe, Hays, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, Palo Pinto, Parker, Runnels, San Saba, Shackelford, Stephens, Sutton, Throckmorton, Tom Green, Travis, and Victoria Counties, Texas, fall within the boundaries of the critical habitat designation. This rule applies the protections of the Act to these species and their designated critical habitats.

Critical Habitat Designation

The critical habitat unit is depicted for DeWitt, Gonzales, and Victoria Counties, Texas. Unit FASP–1: Guadalupe River; DeWitt, Gonzales, and Victoria Counties, Texas. (i) Unit FASP–1 consists of two subunits: (A) Subunit FASP–1a (San Marcos River) consists of 21.2 river miles (mi) (34 kilometers (km)) of the in Gonzales County, Texas. The riparian lands that border this subunit are in State (8 percent) and private (92 percent) ownership. (B) Subunit FASP–1b (Guadalupe River) consists of 122.4 river mi (197 km) of the Guadalupe River in DeWitt, Gonzales, and Victoria Counties, Texas. The riparian lands that border this subunit are in State (2 percent) and private (98 percent) ownership. (ii) Unit FASP–1 includes stream channel up to bankfull height.

Primary Constituent Elements/Physical or Biological Features

Within this area, the physical or biological features essential to the conservation of false spike consist of the following components within waters and streambeds up to the ordinary highwater mark:

(i) Flowing water at rates suitable to keep riffle habitats wetted and welloxygenated and to prevent excess sedimentation but not so high as to dislodge individuals

(ii) Stable riffles and runs with cobble, gravel, and fine sediments

(iii) Blacktail shiner (Cyprinella venusta) and red shiner (C. lutrensis) present;

(iv) Water quality parameters within the following ranges: (A) Dissolved oxygen greater than 2 milligrams per liter (mg/L); (B) Salinity less than 2 parts per thousand; (C) Total ammonia less than 0.77 mg/ L total ammonia nitrogen; (D) Water temperature below 29 °C (84.2 °F); and (E) Low levels of contaminants.

Life History

Food/Nutrient Resources

Food/Nutrient Narrative

Adult: Adult freshwater mussels, including Central Texas mussels, are filter-feeders, siphoning suspended phytoplankton, zooplankton, rotifers, protozoans, detritus and dissolved organic matter from the water column (Strayer et al. 2004, p. 430) and from sediment; juvenile mussels can use their feet to collect food items from sediments (pedal feeding; Vaughn et al. 2008, pp. 409-411). Glochidia derive what little nutrition they need from their obligate fish hosts (Barnhart et al. 2008, p. 372). Stable isotope studies suggest some Central Texas mussels (e.g., Texas pimpleback and Texas fatmucket) are feeding on coarse particulate organic matter (CPOM), or bacteria and fungi adhered to and decomposing CPOM (Bonner et al. 2018, pp. 7, 215). Freshwater mussels must keep their shells open (gaped) to obtain food and facilitate gas exchange, but they often respond to water quality degradations by closing their shells (Bonner et al. 2018, p. 141). Food supply is not generally considered limiting in those environments inhabited by Central Texas mussels. However, food limitation may be important during times of elevated water temperature, as both metabolic demand and incidence of valve closure increases concomitantly, resulting in reduced growth and reproduction (USFWS, 2022)

Lifespan

Adult: ~17 years max (USFWS, 2022)

Dependency on Other Individuals or Species

Adult: • Obligate ectoparasite of fish gills. • red shiner and blacktail shiner (USFWS, 2022)

Reproduction Narrative

Adult: Dudding et al. (2019, p. 16) conducted laboratory studies that tested eight potential species of host fish and reported that false spike glochidia successfully transformed on red shiner (Cyprinella lutrensis) and blacktail shiner (Cyprinella lutrensis). Dudding et al. (2019, p. 16) also reported encountering gravid females during March through April in the Guadalupe River population, and that only 10 of 34 collected gravid females produced viable glochidia that could be infected on possible host fish during the study. Dudding et al. (2019) caution that the patchy distribution of false spike could be related to host fish relationships; that is, because their host fish have a small home range, limited dispersal ability, and are sensitive to human impacts, distribution of false spike could be limited by access to, and movement of host fish (pp. 16-7). Pfeiffer et al. (2016, p. 287) suggested that, based on closely related species, false spike likely brood eggs and larvae from early spring to late summer and that host fish are expected to be minnows (family Cyprinidae). Howells et al. (1996, pp. 127-8) and Howells (2014, p. 85) report the fish hosts as unknown. Members of the tribe Pleurobemini produce conglutinates (Barnhart et al. 2008, p. 376) and tend to exhibit short-term brooding (tachytictia), that is, they release glochidia soon after the larvae mature (Barnhart et al. 2008, p. 384). Conglutinates may be important in protecting glochidia from some water quality contaminants (Barnhart et al. 2008, p. 375), serving as barriers as glochidia physically encased in conglutinates, rather than free-floating, are not directly exposed to waterborne contaminants (including metals such as copper;

Gillis et al. 2008, pp.138, 144). Similar physical protection is also afforded to glochidia when they encyst on host fish. Congeners (Fusconaia spp.) from the southeast United States are reported by Haag and Rypel (2010) to reach a maximum age of 15–51 years (Table 1, pp. 4-6) and members of tribe Pleurobemini ranged from 14–57 years (p. 10). No age at maturity information exists for this species (Howells 2010d, p. 3). However, preliminary and ongoing shell sectioning studies suggest that the species has a maximum life span of about 17 years and frequently lives only for about 10 years (USFWS, 2022).

Habitat Type

Adult: Creek/River (USFWS, 2022)

Habitat Narrative

Adult: False spike occurs in larger creeks and rivers with sand, gravel, or cobble substrates, and with slow to moderate flows, and is not known from impoundments, nor from deep waters (USFWS, 2022)

Dispersal/Migration

Population Information and Trends

Number of Populations:

1 (USFWS, 2022)

Population Size:

>650 (USFWS, 2022)

Population Narrative:

Recent surveys that documented living individuals were conducted in 2011, by Randklev et al. 2011 (pp. 17-18) who report finding 7 live individuals, from near the edge of a gravel bar, in the Guadalupe River near Gonzales, Texas. Mabe and Kennedy (2013, pp. 298-9) observed 8 living false spike and collected recent shells from stable substrates in “a shallow run just upstream of a moderately-sized riffle” of the Lower Guadalupe River near Cuero, Texas, in 2012. The most comprehensive survey of the Lower Guadalupe River was completed in 2014-15 when Tsakiris and Randklev (2016a, p. 13) observed a total of 652 false spike out of a total of over 21,000 mussels. False spike was observed only from riffle habitats, and not below Cuero, Texas, indicating very low abundances in the reaches just above Victoria, Texas. Bonner et al. (2018, p. 37) found no living individuals in the upper Guadalupe River. (USFWS, 2022).

Threats and Stressors

Stressor: Increased fine sediment (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Juvenile and adult Central Texas mussels inhabit microsites that have abundant interstitial spaces, or small openings in an otherwise closed matrix of substrate, created by gravel, cobble, boulders, bedrock crevices, tree roots, and other vegetation, with some amount of fine sediment (i.e., clay and silt) necessary to provide appropriate shelter. However, excessive

amounts of fine sediments can reduce the number of appropriate microsites in an otherwise suitable mussel bed by filling in these interstitial spaces and can smother mussels in place. Central Texas mussels generally require stable substrates, and loose silt deposits do not generally provide for substrate stability. Interstitial spaces provide essential habitat for juvenile mussels. Juvenile freshwater mussels burrow into interstitial substrates, making them particularly susceptible to degradation of this habitat feature. When clogged with sand or silt, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability. While adult mussels can be physically buried by excessive sediment, "the main impacts of excess sedimentation on unionids are often sublethal" and include interference with feeding mediated by valve closure (Brim Box and Mossa 1999, p. 101). Many land use activities can result in excessive erosion, sediment production and channel instability; including, but not limited to, logging, crop farming, ranching, mining, and urbanization (Brim Box and Mossa 1999, p. 102). Under a natural flow regime, a river or stream is in equilibrium in the context of sediment load, such that as sediments are naturally washed away from one microsite to another and the amount of sediment in the substrate is relatively stable, given that different reaches within a river or stream may be aggrading or degrading sediment (Poff et al. 1997, pp. 770-2). Current and past human activities result in enhanced sedimentation in river systems and legacy sediment, resulting from past land disturbance and reservoir construction, continues to persist and influence river processes and sediment dynamics (Wohl 2015, p. 31, pp. 39-42) and these legacy effects can result in degradation of mussel habitats. Fine sediments collect on the streambed and in crevices during low flow events, and much of the sediment is washed downstream during high flow events (also known as cleansing flows) and deposited elsewhere. However, increased frequency of low flow events (from groundwater extraction, instream surface flow diversions, and drought) combined with a decrease in cleansing flows (from reservoir management and drought) causes sediment to accumulate. Sediments deposited by large scale flooding or other disturbance may persist for several years until adequate cleansing flows can redistribute that sediment downstream. When water velocity decreases, which can occur from reduced streamflow or inundation, water loses its ability to carry sediment in suspension; sediment falls to the substrate, eventually smothering mussels not adapted to soft substrates (Watters 2000, p. 263). Sediment accumulation can be exacerbated when there is a simultaneous increase in the sources of fine sediments in a watershed. In the range of the Central Texas mussels, these sources include streambank erosion from development, agricultural activities, livestock and wildlife grazing and browsing, in-channel disturbances, roads, and crossings, among others (Poff et al. 1997, p. 773). In areas with ongoing development, runoff can transport substantial amounts of sediment from ground disturbance related to construction activities with inadequate or absent sedimentation controls. While these construction impacts can be transient (lasting only during the construction phase), the long-term effects of development are long lasting and can result in hydrological alterations as increased impervious cover increases run off and resulting shear stress causes streambank instability and additional sedimentation (USFWS, 2022).

Stressor: Changes in water quality (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Above all else, freshwater mussels require water in sufficient quantity and quality on a consistent basis to complete their life cycles and those of their host fish. Urban growth and other anthropogenic activities across Texas are placing increased demands on limited water supplies

that in turn, can have deleterious effects on water quality. Water quality can be degraded through contamination or alteration of water chemistry. Chemical contaminants are ubiquitous throughout the environment and are a major reason for the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Chemicals enter the environment through both point and nonpoint source discharges, including hazardous spills, industrial wastewater, municipal effluents, and agricultural runoff. These sources contribute organic compounds, trace metals, pesticides, and a wide variety of newly emerging contaminants (e.g., pharmaceuticals) that comprise some 85,000 chemicals in commerce today that are released to the aquatic environment (EPA 2018, p. 1). The extent to which environmental contaminants adversely affect aquatic biota can vary depending on many variables such as concentration, volume, and timing of the release, but species diversity and abundance consistently ranks lower in waters that are known to be polluted or otherwise impaired by contaminants. Freshwater mussels are not generally found for many miles downstream of municipal wastewater treatment plants (Gillis et al. 2017, p. 460; Goudreau et al. 1993, p. 211; Horne and McIntosh, p. 119). For example, transplanted common freshwater mussels (Amblema plicata and Corbicula fluminea) showed reduced growth and survival below a wastewater treatment plant (WWTP) outfall relative to sites located upstream of the WWTP in Wilbager Creek (a tributary to the Colorado River in Travis County, Texas). Water chemistry was altered by the wastewater flows at downstream sites, with elevated constituents in the water column that included copper, potassium, magnesium, and zinc (Nobles and Zhang 2015, p.11; Duncan and Nobles 2012, p. 8). Contaminants released during hazardous spills are also of concern. Although spills are relatively short-term events and may be localized, depending on the types of substances and volume released, water resources nearby can be severely impacted and degraded for years after the incident (USFWS, 2022).

Stressor: Altered hydrology (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Inundation. Flow loss and scour.

Stressor: Predation, Collection, Disease, and Invasive Species (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Predation on freshwater mussels is a natural ecological interaction. Raccoons, snapping turtles, and fish are known to prey upon Central Texas mussels. Under natural conditions, the level of predation occurring within Central Texas mussel populations is not likely to pose a significant risk to any given population. However, during periods of low flow, terrestrial predators have increased access to portions of the river that are otherwise too deep under normal flow conditions. High levels of predation during drought have been observed on the Llano and San Saba rivers. As drought and low flow are predicted to occur more often and for longer periods due to the effects of future climate change, the Hill Country tributaries (of the Colorado River) in particular are expected to experience additional predation pressure into the future, and this may become especially problematic in the Llano and San Saba Rivers. Predation is expected to be less of a problem for the lower portions of the main stem river populations, as the rivers are significantly larger than the tributary streams and Central Texas mussels are thus less likely to be found in exposed or very shallow habitats. Certain mussel beds within some populations, due

to ease of access, are vulnerable to over-collection and vandalism. These areas, primarily on the Llano and San Saba Rivers, have well known and well documented mussel beds that are often sampled multiple times annually by various researchers for various scientific projects. Given the additional stressors aforementioned in this chapter, these populations are being put at additional risk due to over collection and over harvest for scientific needs. Service biologists recently hosted what is planned to be an annual mussel research and coordination meeting to help adaptively manage monitoring and scientific collection of certain populations and foster increased collaboration among researchers (USFWS, 2022).

Stressor: Barriers to Fish Movement (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Central Texas mussels historically colonized new areas through movement of infested host fish, as newly metamorphosed juveniles would excyst from host fish in new locations. Today, the remaining Central Texas mussel populations are significantly isolated from one another by major reservoirs such that recolonization of areas previously extirpated is extremely unlikely if not impossible due to existing contemporary barriers to host fish movement. There is currently no opportunity for interaction among any of the extant Central Texas mussel populations as they are all fragmented from one another by reservoirs. The overall distribution of mussels is, in part, a function of the dispersal of their host fish. There is limited potential for immigration between populations other than through the attached glochidia being transported to a new area or to another population. Small populations are more affected by this limited immigration potential because they are susceptible to genetic drift, resulting from random loss of genetic diversity, and inbreeding depression. At the species level, populations that are eliminated due to stochastic events cannot be recolonized naturally, leading to reduced overall redundancy and representation. Many of the Central Texas mussels known or assumed primary host fish species are known to be common, widespread species in the Central Texas river basins. We know that populations of mussels and their host fish have become fragmented and isolated over time following the construction of major dams and reservoirs throughout Central Texas. We do not currently have information demonstrating that the distribution of host fish is a factor currently limiting the distribution of Central Texas mussel species. However, a recent study suggested that the currently restricted distribution of false spike, Guadalupe orb, and other related species, could be related to declining abundance of their host fish, particularly those fish having small home ranges and specialized habitat affinities (e.g., Dudding et al. 2019, entire). Further research into the relationships between each of the Central Texas mussel species and their host fish is needed to more fully examine the possible role of declining host fish abundance in explaining mussel population declines (USFWS, 2022).

Stressor: Climate change (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Climate change has been documented as has already taken place, and continued greenhouse gas emissions at or above current rates will cause further warming (Intergovernmental Panel on Climate Change (IPCC) 2013, pp. 11-12). Warming in Texas is expected to be greatest in the summer (Maloney et al. 2014, p. 2236, Fig. 3). In Texas, the number of extremely hot days (high temperatures exceeding 95º Fahrenheit) is expected to

double by around 2050 (Kinniburgh et al. 2015, p. 83). West Texas is an area expected to show greater responsiveness to the effects of climate change (Diffenbaugh et al. 2008, p. 3). Changes in stream temperatures are expected to reflect changes in air temperature, at a rate of approximately 0.6 – 0.8°C increase in stream water temperature for every 1°C increase in air temperature (Morrill et al. 2005, pp. 1-2, 15) and with implications for temperature-dependent water quality parameters such as DO and ammonia toxicity. Given that the Central Texas mussels exist at or near the ecophysiogical edge of climate and habitat gradients of unionid biogeography in North America, it is likely that they may be particularly vulnerable to future climate changes in combination with current and future stressors (Burlakova et al. 2011a, pp. 156, 161, 163; Burlakova et al. 2011b, pp. 395, 403). While projected changes to rainfall in Texas are small (USGCRP 2017, p. 217), higher temperatures caused by anthropogenic forcings leads to increased soil water deficits because of higher rates of evapotranspiration, and is likely to result in increasing drought severity in future climate scenarios just as "extreme precipitation, one of the controlling factors in flood statistics, is observed to have generally increased and is projected to continue to do so across the United States in a warming atmosphere" (USGCRP 2017, p. 231). Even if precipitation and groundwater recharge remain at current levels, increased groundwater pumping and resultant aquifer shortages due to increased temperatures are nearly certain (Loaiciga et al. 2000, p. 193; Mace and Wade 2008, pp. 662, 664-665; Taylor et al. 2013, p. 3). Higher temperatures are also expected to lead to increased evaporative losses from reservoirs, which could negatively affect downstream releases and flows (Friedrich et al. 2018). Effects of climate change, such as air temperature increases and an increase in drought frequency and intensity, have been shown to be occurring throughout the range of Central Texas mussels (USGCRP 2017, p. 188; Andreadis and Lettenmaier 2006, p. 3), and these effects are expected to exacerbate several of the stressors discussed above, such as water temperature and flow loss (Wuebbles et al. 2013, p. 16). A recent review of future climate projections for Texas concludes that both droughts and floods could become more common in Central Texas, and projects that years like 2011 (the warmest on record) could be commonplace by the year 2100 (Mullens and McPherson 2017, pp. 3, 6). This trend of more frequent drought is attributed to increases in hot temperatures, and the number of days at or above 100°F are projected to "increase in both consecutive events and the total number of days" (Mullens and McPherson 2017, p. 14-15). Similarly, floods are projected to become more common and severe because of increases in the magnitude of extreme precipitation (Mullens and McPherson 2017, p. 20). In the analysis of the future condition of the Central Texas mussels, which follows as Chapter 7, climate change is considered to be an exacerbating factor, contributing to the increase of fine sediments, changes in water quality, loss of flowing water, and predation (USFWS, 2022).

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2022. Species Status Assessment Report for the Central Texas Mussels: False spike (Fusconaia mitchelli) Balcones spike (Fusconaia iheringi) Texas fatmucket (Lampsilis bracteata) Texas fawnsfoot (Truncilla macrodon) Texas pimpleback (Cyclonaias petrina) Guadalupe fatmucket (Lampsilis bergmanni) Guadalupe orb (Cyclonaias necki). Version 2.1. USFWS. Region 2. Albuquerque, NM. 267 Pp.

89 FR Vol. 89, No. 108. Pages 48034-48130. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, Balcones Spike, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. Final Rule.

USFWS. 2022. Species Status Assessment Report for the Central Texas Mussels: False spike (Fusconaia mitchelli) Balcones spike (Fusconaia iheringi) Texas fatmucket (Lampsilis bracteata) Texas fawnsfoot (Truncilla macrodon) Texas pimpleback (Cyclonaias petrina) Guadalupe fatmucket (Lampsilis bergmanni) Guadalupe orb (Cyclonaias necki). Version 2.1. USFWS. Region 2. Albuquerque, NM. 267 Pp.

SPECIES ACCOUNT: *Fusconaia rotulata* (Round Ebonyshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; October 10, 2012; Southeast Region (R4) (USFWS 2012)

Physical Description

The round ebonyshell (Fusconaia rotulata, Wright 1899) is a medium sized freshwater mussel. It is round to oval in shape and reaches about 70 mm (2.8 in.) in length. The shell is thick and the exterior is smooth and dark brown to black in color. The shell interior is white to silvery and iridescent (Williams and Butler 1994, p. 61; Williams et al. 2008, p. 319). (USFWS 2012).

Taxonomy

The round ebonyshell belongs to the family Unionidae. The round ebonyshell was originally described by B.H. Wright in 1899 and placed in the genus Unio. Simpson (1900) reexamined the type specimen and assigned it to the genus Obovaria. Based on shell characters, Williams and Butler (1994, p. 61) recognized it as clearly a species of the genus Fusconaia, and its placement in the genus is supported genetically (Lydeard et al. 2000, p. 149) (USFWS 2012). Since listing, the Round Ebonyshell was reassigned to the genus Reginaia (from Fusconaia). The genus includes two other species, Reginaia ebenus and Reginaia apalachicola. Reginaia ebenus is widespread in Gulf Coast river systems, including the Mississippi basin. Reginaia apalachicola is known only from prehistoric archeological sites in the Apalachicola basin and is considered extinct (Williams and Fradkin 1999, Campbell and Lydeard 2012a, b). The genus was formerly corrected for the species listed under protections of the Act (50 CFR 17.11) in the Federal Register to be consistent with this updated taxonomy (i.e., changed to Reginaia rotulata) on February 17, 2022 (87 FR 8960). The current nomenclature is consistent with Williams et al. (2017) and Graf and Cummings (2021) (USFWS, 2022).

Historical Range

The round ebonyshell (Fusconaia rotulata, Wright 1899) is a medium sized freshwater mussel endemic to the Escambia River drainage in Alabama and Florida (Williams et al. 2008, p. 320) (USFWS 2012).

Current Range

The round ebonyshell is extremely rare, and its distribution is restricted to the main channel of the Escambia-Conecuh River. Due to recent survey data, its known range was extended downstream the Escambia River to Molino, Florida (Gangloff 2012 pers. comm.), and upstream in the Conecuh River to just above the Covington County line in Alabama (Williams et al. 2008, p. 320) (USFWS 2012).

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On October 10, 2012, the U.S. Fish and Wildlife Service designated critical habitat for the round ebonyshell (Fusconaia rotulata), under the Endangered Species Act of 1973, as amended (77 FR 61663 - 61719).

Critical Habitat Designation

Critical habitat for the round ebonyshell is designated in GCM1: Lower Escambia River.

Unit GCM1: Lower Escambia River Drainage, Florida and Alabama. Unit GCM1 encompasses 558 km (347 mi) of the lower Escambia River mainstem and 12 tributary streams in Escambia and Santa Rosa Counties, FL, and Escambia, Covington, Conecuh, and Butler Counties, AL. The unit consists of the main channel of the EscambiaConecuh River from the confluence of Spanish Mill Creek, Escambia and Santa Rosa counties, FL, upstream 204 km (127 mi) to the Point A Lake dam, Covington County, AL; Murder Creek from its confluence with the Conecuh River, Escambia County, AL, upstream 62 km (38 mi) to the confluence of Cane Creek, Conecuh County, AL; Burnt Corn Creek from its confluence with Murder Creek, Escambia County, AL, upstream 59 km (37 mi) to County Road 20, Conecuh County, AL; Jordan Creek from its confluence with Murder Creek, upstream 5.5 km (3.5 mi) to Interstate 65, Conecuh County, AL; Mill Creek from its confluence with Murder Creek upstream 2.5 km (1.5 mi) to the confluence of Sandy Creek, Conecuh County, AL; Sandy Creek from its confluence with Mill Creek upstream 5.5 km (3.5 mi) to County Road 29, Conecuh County, AL; Sepulga River from its confluence with the Conecuh River upstream 69 km (43 mi) to the confluence of Persimmon Creek, Conecuh County, AL; Bottle Creek from its confluence with the Sepulga River upstream 5.5 km (3.5 mi) to County Road 42, Conecuh County, AL; Persimmon Creek from its confluence with the Sepulga River, Conecuh County, upstream 36 km (22 mi) to the confluence of Mashy Creek, Butler County, AL; Panther Creek from its confluence with Persimmon Creek upstream 11 km (7 mi) to State Route 106, Butler County, AL; Pigeon Creek from its confluence with the Sepulga River, Conecuh and Covington Counties, upstream 89 km (55 mi) to the confluence of Three Run Creek, Butler County, AL; and Three Run Creek from its confluence with Pigeon Creek upstream 9 km (5.5 mi) to the confluence of Spring Creek, Butler County, AL. Unit GCM1 is within the geographical area occupied at the time of listing (2012) for the round ebonyshell, southern kidneyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Escambia River system is within the species' historical range, and we consider it essential to the southern kidneyshell's conservation due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. The unit currently supports populations of round ebonyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, cooccur with these five species. A diverse fish fauna, including potential fish host(s) for the fuzzy pigtoe, are known from the Escambia River drainage, indicating the potential presence of PCE 5. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to two upstream impoundments. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Primary Constituent Elements/Physical or Biological Features

Within critical habitat areas, the primary constituent elements of the physical or biological features essential to the conservation of the round ebonyshell consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to this mussel and its habitat are pervasive and common in all of the nine units that are designated as critical habitat. These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas designated as critical habitat are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species (NatureServe 2015).

Reproduction Narrative

Adult: It is believed to be a short-term brooder, and gravid females have been observed in the spring and summer. The fish host(s) for the round ebonyshell is currently unknown (Williams et al. 2008, p. 320) (USFWS 2012). Information gaps continue to exist for all seven species, however, based on mussel life history strategies, we do know that the Round Ebonyshell, Tapered Pigtoe, Narrow Pigtoe, and Fuzzy Pigtoe are grouped with species that typically exhibit low to moderate growth rates, long life spans (>25 years), and late maturity (>3 years) (USFWS, 2022)

Geographic or Habitat Restraints or Barriers

Adult: Dams (see dispersal/migration narrative)

Spatial Arrangements of the Population

Adult: Linear (USFWS 2012)

Environmental Specificity

Adult: Narrow (inferred from USFWS 2012)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS 2012)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: It occurs in small to medium rivers, typically in stable substrates of sand, small gravel, or sandy mud in slow to moderate current. The habitat is linear in nature. Primary constituent elements include (1) Geomorphically stable stream and river channels and banks (2) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae (3) A hydrologic flow regime necessary to maintain benthic habitats and connectivity of rivers with the floodplain (4) Water quality, including temperature (not greater than 32 oC), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 mg/L) (USFWS 2012).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low - moderate (inferred from NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: By blocking fish movement, the dams may prevent gene exchange between upstream and downstream mussel populations (USFWS 2012). The greatest potential for migration is during the glochidial stage on fish. Adults of this species are essentially sessile however some passive movement downstream may occur during high flows (NatureServe 2015).

Population Information and Trends

Population Trends:

Declining (NatureServe 2015)

Number of Populations:

1 - 5 (NatureServe 2015)

Population Size:

50 - 1,000 (NatureServe 2015)

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

It is unknown if any of the eight mussel species are currently experiencing a loss of genetic diversity (USFWS 2012). The range extent of this species is less than 40 square miles, with 1 - 5 occurrences, and a population size of 50 - 1,000 individuals. None of these occurrence have good/viability/integrity. Recent status surveys indicated that this species has experienced severe range reductions and occurs in low abundance within its limited range. Only 3 of 9 historic locations contain living individuals, thereby indicating a 67% decline in the number of sites known to support this species (see USFWS, 2003) (NatureServe 2015). Round Ebonyshell records are known from the Escambia River basin in Alabama and Florida (Fig. 3). Historical records (prior to 2000) are limited to 20 collections consisting of six live individuals and shell material of 24 individuals. Live collections are rare because it is challenging to sample deep, mainstem habitats where the species occurs. The use of SCUBA gear has increased the detection of live individuals and resulted in recent observations of 17 live mussels. However, the scarcity of historical records makes it difficult to examine abundance trends. Round Ebonyshell current (2000–2021) occurrences are discussed below and summarized by subbasin in Appendix A. The Round Ebonyshell's status in Alabama is uncertain due to limited surveying in the Conecuh River since 2000, and additionally, some remote reaches of the river have never been surveyed. Current observations include nine live individuals and three shells collected at four locations. The Round Ebonyshell may have been extirpated from some areas, including the reach around the Alabama-Florida state line (near Pollard, Alabama). It has not been detected in this reach since three shells were found in 1998. Severe channel instability has deteriorated stable habitat in this reach. The Round Ebonyshell appears extant throughout its Florida range but is extremely rare. Despite a considerable amount of survey effort in the Escambia River, FL since 2000, only eight live individuals and three shells were documented at four locations. Targeted surveys found the species in extremely low densities relative to other native mussel species detected. Using survey methods suitable for detecting Round Ebonyshell, surveyors found two live individuals, which comprised 0.09% of the collective sample. The Round Ebonyshell has only been documented in a 150 km (93 mi) reach of the EscambiaConecuh River. However, the full extent of its range is difficult to determine due to limited historical data (20 collection records), some with only vague locality data, and difficulty in sampling for the species. In addition, no Round Ebonyshell collections are known from the Conecuh River, AL prior to construction of the Point A and Gantt dams in the 1920s. There is no indication that the species' distribution has changed substantially since being listed. Recent surveys have documented its persistence in the Florida portion of the mainstem. However, it may be locally extirpated in the reach around the state line, where it has not been detected since 1998. Limited survey data indicates the species is extant in the Conecuh River, however, too few surveys have been conducted in this reach to accurately assess its status in this portion of its historical range. Historical and current Round Ebonyshell occurrences are shown in Figure 3. (USFWS, 2022)

Threats and Stressors

Stressor: Pollution (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Nonpoint-source pollution from land surface runoff originates from virtually all land use activities and includes sediments, fertilizer, herbicide and pesticide residues; animal wastes; septic tank leakage and gray water discharge; and oils and greases. Current activities and land uses that can negatively affect populations of these eight mussels include unpaved road crossings, improper silviculture and agriculture practices, highway construction, housing developments, pipeline crossings, and cattle grazing. Land surface runoff also contributes nutrients (for example, nitrogen and phosphorus from fertilizers, sewage, and animal manure) to rivers and streams, causing them to become eutrophic. Excessive nutrient input stimulates excessive plant growth (algae, periphyton attached algae, and nuisance plants). This enhanced plant growth can cause dense mats of filamentous algae that can expose juvenile mussels to entrainment or predation and be detrimental to the survival of juvenile mussels (Hartfield and Hartfield 1996, p. 373). Excessive plant growth can also reduce dissolved oxygen in the water when dead plant material decomposes. Because of their sedentary characteristics, mussels are extremely vulnerable to toxic effluents (Sheehan et al. 1989, pp. 139–140; Goudreau et al. 1993, pp. 216–227; Newton 2003, p. 2543). (USFWS 2012)

Stressor: Sedimentation (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Sedimentation is one of the most significant pollution problems for aquatic organisms (Williams and Butler 1994, p. 55), and has been determined to be a major factor in mussel declines (Ellis 1936, pp. 39–40). Impacts resulting from sediments have been noted for many components of aquatic communities. For example, sediments have been shown to abrade or suffocate periphyton (organisms attached to underwater surfaces); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters 1995, pp. 173– 175). Heavy sediment loads can destroy mussel habitat, resulting in a corresponding shift in mussel fauna (Brim Box and Mossa 1999, p. 100). Excessive sedimentation can lead to rapid changes in stream channel position, channel shape, and bed elevation (Brim Box and Mossa 1999, p. 102). Sedimentation has also been shown to impair the filter feeding ability of mussels. When in high silt environments, mussels may keep their valves closed more often, resulting in reduced feeding activity (Ellis 1936, p. 30),

and high amounts of suspended sediments can dilute their food source (Dennis 1984, p. 212). Increased turbidity from suspended sediment can reduce or eliminate juvenile mussel recruitment (Negus 1966, p. 525; Brim Box and Mossa 1999, pp. 101–102). Many mussel species use visual cues to attract host fishes; such a reproductive strategy depends on clear water. Potential sediment sources within a watershed include virtually any activity that disturbs the land surface. Current sources of sand, silt, and other sediment accumulation in south-central Alabama and western Florida stream channels include unpaved road runoff, agricultural lands, timber harvest, livestock grazing, and construction and other development activities (Williams and Butler 1994, p. 55; Bennett 2002, p. 5 and references therein; Hoehn 1998, pp. 46–47 and references therein). (USFWS 2012)

Stressor: Channel instability (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Mussels require stable stream and river habitats and activities that cause channel instability can negatively impact their populations. Activities such sand and gravel mining, the removal of large woody material, off-road vehicles use, and land use changes are known to cause channel destabilization. Activities that destabilize stream beds and channels can result in drastic alterations to stream geomorphology and consequently to the stream's ecosystem. Instream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, p. 10; Hartfield 1993, pp. 138–139). Poorly located or inadequately designed mines in the flood plain can have similar effects and result in alterations to streams channels (Mossa and Coley, 2004, p. 2). Land use activities such as land clearing and development can cause channel instability by accelerating storm water runoff into streams. (USFWS 2012)

Stressor: Impoundments (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The damming of rivers has been a major factor contributing to the demise of freshwater mussels (Bogan 1993, p. 604). Dams eliminate or reduce river flow within impounded areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, affect normal flood patterns, and block upstream and downstream movement of mussels and their host fishes (Bogan 1993, p. 604; Vaughn and Taylor 1999, pp. 915–917; Watters 1999, pp. 261–264; McAllister et al. 2000, p. iii; Marcinek et al. 2005, pp. 20–21). Downstream of dams, mollusk declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels, water temperatures, and changes in resident fish assemblages (Williams et al. 1993, p. 7; Neves et al. 1997, pp. 63–64; Watters 1999, pp. 261– 264; Marcinek et al. 2005, pp. 20–21). (USFWS 2012)

Stressor: Stochastic events (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may contribute to the further decline of mussel populations

suffering the effects of other threats. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin et al. 2002, p. 6074; Golladay et al. 2004, p. 504; Cook et al. 2004, p. 1015). Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in stream temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions. (USFWS 2012)

Stressor: Small, isolated populations (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153). (USFWS 2012)

Stressor: Nonindigenous species (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The Asian clam (Corbicula fluminea) has been introduced to the drainages and may be adversely affecting these eight mussels through direct competition for space and resources. Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles, and may actively disturb sediments, reducing habitable space for juvenile native mussels, or displacing them downstream (Strayer 1999, p. 82; Yeager et al. 2000, pp. 255–256). The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations. Biologists working in the Florida portions of these drainages have observed a correlation between the increase in flathead catfish numbers and a decrease in numbers of other native fish species, particularly of bullhead catfish (Ameiurus sp.) and redbreast sunfish (Lepomis auritus) (Strickland 2010 pers. comm.). (USFWS 2012)

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 5

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.
- Maintain high water and benthic habitat (substrate) qualities, as well as adequate flow regimes, throughout the Escambia/Conecuh River system. This may be partially accomplished via establishment of buffers and streamside management zones for all

agricultural, silvicultural, mining, and developmental activities; protection of floodplain forests and adjoining upland habitat is paramount (NatureServe 2015).

- Best management practices include employing forestry practices that cause minimal soil erosion; preventing access of livestock to natural surface waters and drains; situating roads at least 0.25 mi. (0.4 km) from heads of all tributaries, even more on steep slopes; using silt fencing and vegetation to control runoff and siltation at all stream crossings, especially during construction and maintenance; using and maintaining sewer systems rather than septic tanks and stream-dumping for management of wastewater; and avoiding use of agricultural pesticides on porous soils near streams (NatureServe 2015).
- Prevent damming, dredging, and pollution throughout drainages, but especially near recorded sites. Remove existing dams, but with great care to limit downstream sedimentation. Limit withdrawal of surface and subterranean waters as necessary to maintain normal stream flows, especially during drought (NatureServe 2015).
- Prevent or limit establishment of invasive species (including zebra mussel, Dreissena polymorpha) to the extent possible (NatureServe 2015).
- Where appropriate, protect populations through acquisitions and easements over streamside lands by working with government agencies and conservation organizations. See also U.S. Fish and Wildlife Service (2003) (NatureServe 2015).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES These seven species do not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities, which are included below. Recovery Activities a. Encourage the protection and establishment of wide riparian buffer zones along all streams containing or draining into the historical ranges of these species. Buffers of at least 300 feet in width and consisting of native forest are considered the most protective and effective. A greater width may be necessary to effectively buffer storm water runoff from urban and suburban lands, cultivated fields, and timber harvest operations. b. Restore and increase in-stream habitat and stream connectivity through conservation actions, including but not limited to removing artificial fish migration barriers, bank stabilization, riparian buffer maintenance or augmentation, improving water quality downstream of impoundments, and adherence to BMPs. c. Work with state and federal agencies and private organizations to promote land and water stewardship awareness (e.g., Soil and Water Conservation Districts, Natural Resource Conservation Service (NRCS), State Forestry Commissions, private industry groups, environmental groups, etc.). d. Develop programs and outreach materials to increase public awareness of these species and explain the benefits of protecting stream ecosystems. Monitoring and Research Activities a. Conduct status survey for Round Ebonyshell in the Conecuh River and document habitat conditions. b. Conduct surveys in under sampled portions of their ranges to examine the species' status and habitat conditions. c. Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. d. Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, and age-specific survival. e. Use eDNA as a detection tool to provide up-to-date distributional information, especially for rare or cryptic species like Southern Kidneyshell. Use assays to confirm presence in historical reaches and detect previously unknown populations. f. Conduct long-term monitoring studies of stream thermal regimes, especially during summer low flow conditions. g. Prepare a comprehensive threats assessment that identifies and maps existing and potential threats within the watersheds and identifies activities or practices that may affect the seven mussels or their habitats. Use the assessment to develop SSAs and recovery plans for the species. h. Model future precipitation, temperature, and flow scenarios in the basins to examine the impacts of climate change and consumptive uses. Use the assessment to develop SSAs and recovery plans for the species. i. Model future sea level and flow scenarios to analyze the effects of saltwater encroachment in the lower mainstems during high tide and storm surge events. Use the assessment to develop SSAs and recovery plans for the species. j. Research important life-history traits, such as host fish use, growth, longevity, age at maturity, and fecundity, and incorporate the results into management and protection actions. All partners should be aware of research efforts and results to facilitate the immediate application of results. k. Determine temperature and contaminant sensitivity for each life-stage, and develop recommendations for EPA and state water quality criteria to protect and enhance habitat. l. Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans. m. Study the life history and identify the host fish of the Southern Sandshell, Choctaw Bean, and Round Ebonyshell (USFWS, 2022).

References

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 FR 61663 - 61719 (October 10, 2012).

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016). USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 28, 2016).

USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

SPECIES ACCOUNT: *Fusconaia subrotunda* (Longsolid)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

Longsolid adult mussels are light brown in color, but darken with age. The shell is thick and medium-sized (up to 5 inches (in) (125 millimeters (mm)), and typically has a dull sheen (Williams et al. 2008, p. 322). There is variability in the inflation of the shell depending on population and latitudinal location (Ortmann 1920, p. 272; Watters et al. 2009, p. 130). Juveniles usually have a bold green ray pattern near the umbo (the raised portion of the dorsal margin of mussel shell), and the Longsolid shell becomes more elongate as it ages. The umbo cavity is wide, compressed, and typically deep, which is a key characteristic of the shell. The foot can be orange, pale orange, or white (USFWS, 2018).

Taxonomy

● Phylum: Mollusca ● Class: Bivalvia ● Order: Unionoida ● Family: Unionidae ● Subfamily: Ambleminae ● Tribe: Pleurobemini ● Genus: Fusconaia ● Species: subrotunda

Historical Range

The Longsolid is known historically from 160 populations and 105 MUs in 12 states. It occurred in the Great Lakes, Ohio, Cumberland, and Tennessee River basins. Within the Great Lakes basin, it occurred only in the US portion, not in Canada (Appendix D). The Longsolid is considered extirpated from the Great Lakes basin, which historically had at least six populations distributed across four MUs (USFWS, 2018).

Current Range

60 populations currently known to be extant in 45 MUs. The results of surveys conducted since 2000 indicate the currently occupied range of the Longsolid includes 60 rivers and streams, however, it no longer occurs in the Great Lakes basin. (USFWS, 2018).

Critical Habitat Designated

Yes; 4/10/2023.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine threatened species status under the Endangered Species Act of 1973 (Act), as amended, for the longsolid (Fusconaia subrotunda) and round hickorynut (Obovaria subrotunda), freshwater mussels. We also designate critical habitat for both species. For the longsolid, in total, approximately 1,115 river miles (1,794 river kilometers) fall within 12 units of critical habitat in Pennsylvania, Kentucky, West Virginia, Virginia, Tennessee, and Alabama. For the round hickorynut, in total, approximately 921 river miles (1,482 river kilometers) fall within 14 units of critical habitat in Pennsylvania, Ohio, Indiana, Kentucky, West Virginia, Tennessee, Alabama, and Mississippi.

Critical Habitat Designation

Critical habitat units for the round hickorynut are depicted on the maps in this entry for Jackson, Madison, and Marshall Counties, Alabama; Fulton, Marshall, Pulaski, and Starke Counties, Indiana; Bath, Butler, Campbell, Edmonson, Fleming, Green, Harrison, Hart, Kenton, Laurel, Morgan, Nicholas, Pendleton, Pulaski, Rockcastle, Robertson, Rowan, and Warren Counties, Kentucky; Montgomery County, Mississippi; Bedford, Marshall, and Maury Counties, Tennessee; Ashtabula, Lake, and Trumbull Counties, Ohio; Crawford and Mercer Counties, Pennsylvania; and Braxton, Calhoun, Clay, Doddridge, Fayette, Gilmer, Kanawha, Pleasants, Ritchie, Tyler, and Wood Counties, West Virginia.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of the round hickorynut consist of the following components:

(i) Adequate flows, or a hydrologic flow regime (magnitude, timing, frequency, duration, rate of change, and overall seasonality of discharge over time), necessary to maintain benthic habitats where the species is found and to maintain stream connectivity, specifically providing for the exchange of nutrients and sediment for maintenance of the mussel's and fish host's habitat and food availability, maintenance of spawning habitat for native fishes, and the ability for newly transformed juveniles to settle and become established in their habitats. Adequate flows ensure delivery of oxygen, enable reproduction, deliver food to filter-feeding mussels, and reduce contaminants and fine sediments from interstitial spaces. Stream velocity is not static over time, and variations may be attributed to seasonal changes (with higher flows in winter/spring and lower flows in summer/fall), extreme weather events (e.g., drought or floods), or anthropogenic influence (e.g., flow regulation via impoundments).

(ii) Suitable substrates and connected instream habitats, characterized by geomorphically stable stream channels and banks (i.e., channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with habitats that support a diversity of freshwater mussel and native fish (such as, stable riffle-runpool habitats that provide flow refuges consisting of predominantly silt-free, stable sand, gravel, and cobble substrates).

(iii) Water and sediment quality necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages, including (but not limited to): Dissolved oxygen (generally above 2 to 3 parts per million (ppm)), salinity (generally below 2 to 4 ppm), and temperature (generally below 86 °F (°F) (30 °Celsius (°C)). Additionally, water and sediment should be low in ammonia (generally below 0.5 ppm total ammonia-nitrogen) and heavy metal concentrations, and lack excessive total suspended solids and other pollutants. (iv) The presence and abundance of fish hosts necessary for recruitment of the round hickorynut (i.e., eastern sand dart

(iv) The presence and abundance of fish hosts necessary for recruitment of the round hickorynut (i.e., eastern sand darter (Ammocrypta pellucida), emerald darter (Etheostoma baileyi), greenside darter (E. blennioides), Iowa darter (E. exile), fantail darter (E. flabellare), Cumberland darter (E. susanae), spangled darter (E. obama), variegate darter (E. variatum), blackside darter (Percina maculata), frecklebelly darter (P. stictogaster), and banded sculpin (Cottus carolinae)).

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the longsolid and round hickorynut may require special management considerations or protections to reduce the following threats: (1) Alteration of the natural flow regime (modifying the natural hydrograph and seasonal flows), including water withdrawals, resulting in flow reduction and available water quantity; (2) urbanization of the landscape, including (but not limited to) land conversion for urban and commercial use, infrastructure (pipelines, roads, bridges, utilities), and urban water uses (resource extraction activities, water supply reservoirs, wastewater treatment, etc.); (3) significant alteration of water quality and nutrient pollution from a variety of activities, such as mining and agricultural activities; (4) impacts from invasive species; (5) land use activities that remove large areas of forested wetlands and riparian systems; (6) culvert and pipe installation that creates barriers to movement for the longsolid and round hickorynut, or their host fishes; (7) changes and shifts in seasonal precipitation patterns as a result of climate change; and (8) other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. Management activities that could ameliorate these threats include, but are not limited to: Use of BMPs designed to reduce sedimentation, erosion, and bank destruction; protection of riparian corridors and woody vegetation; moderation of surface and ground water withdrawals to maintain natural flow regimes; improved stormwater management; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the occupied areas we are designating as critical habitat contain the physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection. Special management considerations or protection may be required of the Federal action agency to eliminate, or to reduce to negligible levels, the threats affecting the physical and biological features of each unit.

Life History

Food/Nutrient Resources

Food Source

Adult: Organic matter, microorganisms; Larvae: freshwater fish

Food/Nutrient Narrative

Adult: Adult freshwater mussels within the genus Fusconaia are suspension-feeders that filter water and nutrients to eat. Mussels may shift to deposit feeding, though reasons for this are poorly known and may depend on flow conditions or temperature. Ciliary tracks on the adult foot apparently facilitate this feeding behavior. Their diet consists of a mixture of algae, bacteria, detritus, and microscopic animals (Gatenby et al. 1996, p. 606; Strayer et al. 2004, p. 430). It has also been surmised that dissolved organic matter may be significant source of nutrition (Strayer et al. 2004, p. 431). Such an array of foods, containing essential long-chain fatty acids, sterols, amino acids, and other biochemical compounds, may be necessary to supply total nutritional needs (Strayer et al. 2004, p. 431). For their first several months, juvenile mussels ingest food through their foot and are thus deposit feeders, although they may also filter interstitial pore water and soft sediments (Yeager et al. 1994, p. 221; Haag 2012, p. 26). Due to the mechanism by which food and nutrients are taken in, freshwater mussels collect and absorb toxins (see section 6.1.2, below). Additionally, recent evidence emphasizes the importance to riverine mussels of the uptake and assimilation of detritus and bacteria over that of algae (Nichols and Garling 2000, p. 881) (USFWS, 2018).

Lifespan

Adult: At this time, the best available information suggests that the Longsolid is a relatively long-lived species averaging 25 to 35 years, but given the large size it can attain, possibly living up to 50 years (USFWS, 2018).

Dependency on Other Individuals or Species

Adult: Unknown fish host.

Breeding Season

Adult: gravid from May-July

Other Reproductive Information

Adult: In a life history study of the fine-rayed pigtoe, Bruenderman and Neves (1993, p. 87) give potential surrogate descriptive information for the shape and size of Longsolid conglutinates and fecundity: slender and subcylindrical in shape and approximately 0.24 in (6 mm) long and 0.06 in (1.5 mm) wide, with two layers of tightly aggregated glochidia about 0.03 in (0.8 mm) deep. One conglutinate from each of five females contained a mean of 236 +/- 38.1 embryos or glochidia. Fecundity was approximately 113,000 embryos for the sacrificed female. Undeveloped eggs are infrequent and conglutinates tend to break up when mature (USFWS, 2018).

Reproduction Narrative

Adult: The Longsolid is presumed to have a complex life cycle (see Figure 3-2) that relies on fish hosts for successful reproduction, similar to other mussels. In general, mussels are either male or female (Haag 2012, p. 54). Males release sperm into the water column, which is taken in by the female through the incurrent aperture, where water enters the mantle cavity. The sperm fertilizes eggs that are held within the female's gills in the marsupial chamber. The developing larvae remain in the gill chamber until they mature (called glochidia) and are ready for release. The Longsolid is a short-term brooder, typically gravid from May-July (Gordon and Layzer 1989, p. 50). Host fish species are unknown, but based on other species of Fusconaia, likely hosts are minnows of the family Cyprinidae and genera Campostoma, Cyprinella, Notropis, and Luxilus as well as potentially sculpins of family Cottidae, genus Cottus (USFWS, 2018).

Habitat Type

Adult: Freshwater/benthic

Habitat Vegetation or Surface Water Classification

Adult: Riverine

Dependencies on Specific Environmental Elements

Adult: Slower current

Geographic or Habitat Restraints or Barriers

Adult: Impoundments/lack of current

Spatial Arrangements of the Population

Adult: non- Linear (A non-linear distribution over a large area) (USFWS, 2018)

Environmental Specificity

Adult: Moderate (inferred from USFWS, 2018)

Tolerance Ranges/Thresholds

Adult: Low to moderate (inferred from USFWS, 2018)

Site Fidelity

Adult: High (inferred from USFWS, 2018)

Dependency on Other Individuals or Species for Habitat

Adult: Host fish

Habitat Narrative

Adult: The Longsolid exhibits a preference for sand and gravel in streams and small rivers, but also may be found in coarse gravel and cobble in larger rivers (Gordon and Layzer 1989, p. 24). In streams and rivers they can be found at depths less than 2 ft (31 cm), but in large rivers can be commonly found at depths of 12 to 18 ft (3.7 to 5.5 m) (Parmalee and Bogan 1998, p. 121); but also at depths of over 20 feet (Garner 2018, pers. comm.). In a study of mussel habitat preferences in the lower Clinch River, Virginia, Longsolid were most associated with slower, deeper microhabitats with low shear stress values (Ostby 2005, p. 58), and were placed in a slow-flow tolerant guild, indicating the species has a greater tolerance for pool and run habitats. Additionally, based on this study, the Longsolid is more frequently encountered in the lower reaches of rivers such as the Clinch River (USFWS, 2018).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Host fish dispersal (USFWS, 2018).

Population Information and Trends

Population Trends:

Decreasing (inferred from USFWS, 2018)

Number of Populations:

60 (USFWS, 2018)

Additional Population-level Information:

The overall current condition of the Longsolid indicates the species has limited resiliency: 48 of the 60 populations (80 percent) are in low condition as opposed to just 3 populations (5 percent) in high condition. Threats that are acting upon the high condition populations (Little Kanawha River in West Virginia, the upper Green River in Kentucky, and the Clinch River in Tennessee and Virginia) include habitat and water quality degradation and the introduction of contaminants resulting from wastewater treatment discharges and mining activities, as well as oil and gas exploration (USFWS, 2022).

Population Narrative:

Management units were defined as a HUC 8, which were identified as most appropriate for assessing population-level resiliency. Range-wide species occurrence data were used to create maps indicating the historical and current distribution of Longsolid among management units for each of 60 populations currently known to be extant. Given the large range of the species within the U.S., using management units at this HUC 8 scale allowed larger rivers such as the Allegheny, Ohio, Cumberland, and Tennessee to be summarized into smaller, more manageable areas for analysis and discussion. The HUC 8 management unit approach has also been used for other wide-ranging aquatic species for the purposes of an SSA (USFWS, 2022).

Threats and Stressors

Stressor: Development/Urbanization
Exposure:
Response:
Consequence:
Narrative: Urban development can lead to increased variability in streamflow, typically increasing the extent and volume of water entering a stream after a storm and decreasing the time it takes for the water to travel over the land before entering the stream (Giddings et al. 2009, p. 1). An “impervious surface” refers to all hard surfaces like paved roads, parking lots, roofs, and even highly compacted soils like sports fields. Impervious surfaces prevent the natural soaking of rainwater into the ground and ultimately and gradually seeping into streams (Brabec et al. 2002, p. 499; New Hampshire Estuaries Project (NHEP) 2007, p. 2). Instead, rainwater accumulates and often flows rapidly into storm drains, which rapidly drain to local streams. This results in deleterious effects on streams in three important ways (USGS 2014, pp. 2–5): (1) Water Quantity: Storm drains deliver large volumes of water to streams much faster than would naturally occur, often resulting in flooding and bank erosion that reshapes the channel, and causes substrate instability, resulting in destabilization of bottom sediments. Increased, high velocity discharges can cause species living in streams (including mussels) to become stressed, displaced, or killed by fast moving water and the debris and sediment carried in it. (2) Water Quality: Pollutants (e.g., gasoline, oil drips, fertilizers) that accumulate on impervious surfaces may be washed directly into streams during storm events. (3) Water Temperature: During warm weather, rain that falls on impervious surfaces becomes superheated and can stress or kill freshwater species when it enters streams (USFWS, 2022).

Stressor: Transportation
Exposure:
Response:
Consequence:
Narrative: A major aspect of urbanization is the resultant road development. By its nature, road development increases impervious surfaces as well as land clearing and habitat fragmentation. Roads are generally associated with negative effects on the biotic integrity of aquatic ecosystems, including changes in surface water temperatures and patterns of runoff, sedimentation, adding heavy metals (especially lead), salts, organics, and nutrients to stream systems (Trombulak and Frissell 2000, p. 18). The adding of salts through road-deicing results in high salinity runoff, which is toxic to freshwater mussels. In addition, a major impact of road development is improperly constructed culverts at stream crossings. These culverts act as barriers if flow through the culvert varies significantly from the rest of the stream, or if the culvert ends up being perched, and aquatic organisms, specifically mussel host fishes, cannot

pass through them. Improperly installed culverts alter in-stream habitat, and can cause changes in stream depth, resulting in pools upstream and a destabilized channel downstream of the culvert.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Contaminants contained in point and non-point discharges can degrade water and substrate quality and adversely impact mussel populations. Although chemical spills and other point sources of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result in part from the subtle, pervasive effects of chronic, low-level contamination (Naimo 1995, p. 354). The effects of heavy metals, ammonia, and other contaminants on freshwater mussels were reviewed by Mellinger (1972); Fuller (1974); Havlik and Marking (1987); Naimo (1995); Keller and Lydy (1997); and Newton et al. (2003) (entire). The effects of contaminants such as metals, chlorine, and ammonia are profound on juvenile mussels (Bartsch et al. 2003, p. 2,566; Augspurger et al. 2003, p. 2,571). Juvenile mussels may readily ingest contaminants adsorbed to sediment particles while pedal feeding (Newton and Cope 2007, p. 276). These contaminants also affect mussel glochidia, which are very sensitive to some toxicants; as has been displayed on the Clinch River, which is a stronghold population for the Longsolid (Goudreau et al. 1993, p. 221; Jacobson et al. 1997, p. 2,386; Valenti et al. 2005, p. 1,243). Mussels are noticeably intolerant of heavy metals (Havlik and Marking 1987, p. 4). Even at low levels, certain heavy metals may inhibit glochidial attachment to fish hosts. Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987, pp. 4–9), although chromium, copper, mercury, and zinc also negatively affect biological processes (Naimo 1995, p. 355; Jacobson et al. 1997, p. 2,389; Valenti et al. 2005, p. 1,243). Chronic mercury contamination from a chemical plant on the North Fork Holston River, Virginia, destroyed a diverse mussel fauna downstream of Saltville, Virginia, and potentially contributed to the extirpation of the species from that river.

Stressor: Agricultural Activities
Exposure:
Response:
Consequence:
Narrative: Nutrient Pollution. Pumping for Irrigation. Agriculture Exemptions from Permit Requirements. The advent of intensive row crop agricultural practices has been cited as a potential factor in freshwater mussel decline, and species extirpation, in the eastern United States (Peacock et al. 2005, p. 550). Nutrient enrichment and water withdrawals, threats commonly associated with agricultural activities, may be localized and limited in scope, and have the potential to affect individual Longsolid mussels. However, chemical control using pesticides; including herbicides, fungicides, and insecticides as well as their surfactants and adjuvants, are highly toxic to juvenile and adult freshwater mussels (Bringolf et al. 2007, p. 2,092). Waste from confined animal feeding and commercial livestock operations is another potential source of contaminants that come from agricultural runoff. The concentrations of these contaminants that emanate from fields or pastures may be at levels that can affect an entire population, especially given the highly fragmented distribution of the Longsolid.

Stressor: Dams and Barriers

Exposure:
Response:
Consequence:
Narrative: The effects of impoundments and barriers on aquatic habitats and freshwater mussels are relatively well-documented (Watters 2000, p. 261). This section is intended to be summary of the effects, as opposed to a comprehensive overview, dams and other barriers have on the Longsolid. Extinction/extirpation of North American freshwater mussels can be traced to impoundment and inundation of riffle habitats in all major river basins of the central and eastern U.S. (Haag 2009, p. 107; North Carolina Wildlife Resources Commission (NCWRC) 2015, p. 109). Humans have constructed dams for a variety of reasons: flood prevention, water storage, electricity generation, irrigation, recreation, and navigation (Eissa and Zaki 2011, p. 253). Dams, either natural (by beavers or by aggregations of woody debris) or man-made, have many impacts on stream ecosystems. Reductions in the diversity and abundance of mussels are primarily attributed to habitat shifts caused by impoundments (Neves et al. 1997, p. 63). The survival of mussels and their overall reproductive success are influenced: ● Upstream of dams – the change from flowing to impounded waters, increased depths, increased buildup of sediments, decreased dissolved oxygen, and the drastic alteration in resident fish populations. ● Downstream of dams – fluctuations in flow regimes, minimal releases and scouring flows, seasonal dissolved oxygen depletion, reduced or increased water temperatures, and changes in fish assemblages.

Stressor: Changing Climate Conditions
Exposure:
Response:
Consequence:
Narrative: Changing conditions that can influence freshwater mussels include changing water temperature and changes in precipitation patterns that increase flooding, prolong droughts, or reduce stream flows, as well as changes in salinity levels (Nobles and Zhang, 2011 pp. 147–148). An increase in the number of days with heavy precipitation over the next 25-35 years over the range of the Longsolid is expected (https://science2017.globalchange.gov/chapter/7/). Although the effects of climate change have potentially affected the Longsolid, the timing, frequency, and extent of these effects is currently unknown.

Stressor: Resource Extraction
Exposure:
Response:
Consequence:
Narrative: Coal mining. Natural gas extraction. Gravel mining/extraction.

Stressor: Forest Conversion
Exposure:
Response:
Consequence:
Narrative: A forested landscape provides many ideal conditions for aquatic ecosystems. Depending on the structure and function of the forest, and particularly if native, natural mixed hardwood-conifer forests comprise the active river area (ARA), rain is allowed to slowly infiltrate and percolate (as opposed to rapid surface runoff), a variety of food resources enter the stream and river via leaf litter and woody debris, banks are stabilized by tree roots, habitat is created by occasional wind throw, and riparian trees shade the stream or river and maintain thermal

climate. Silvicultural activities, when performed according to strict Forest Practices Guidelines (FPG) or BMPs, can retain adequate conditions for aquatic ecosystems (Warrington et al. 2017, p. 8); however, when FPGs or BMPs are not followed, these activities can also cause measurable impacts and contribute to the myriad of stressors facing aquatic systems throughout Eastern U.S. Both small and large-scale forest conversion activities have been shown to have a significant impact depending on the physical, chemical, and biological characteristics of adjacent streams.

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

USFWS. 2018. Draft Species Status Assessment Report for the Longsolid Mussel (Fusconaia subrotunda), Version 1.X3. Asheville Ecological Services Field Office, Asheville, North Carolina.

USFWS. 2023. Endangered and Threatened Wildlife and Plants

Threatened Species Status With Section 4(d) Rule for Longsolid and Round Hickorynut and Designation of Critical Habitat. Final Rule. FR Vol. 88, No. 46. Pages 14794-14869.

USFWS. 2018. Draft Species Status Assessment Report for the Longsolid Mussel (Fusconaia subrotunda), Version 1.X3. Asheville Ecological Services Field Office, Asheville, North Carolina.

USFWS. 2018. Draft Species Status Assessment Report for the Longsolid Mussel (Fusconaia subrotunda), Version 1.X3. Asheville Ecological Services Field Office, Asheville, North Carolina.
USFWS. 2022. Species Status Assessment Report for the Longsolid (Fusconaia subrotunda). Version 1.4. U.S. Fish and Wildlife Service. Region 4. Atlanta, GA.

USFWS. 2022. Species Status Assessment Report for the Longsolid (Fusconaia subrotunda). Version 1.4. U.S. Fish and Wildlife Service. Region 4. Atlanta, GA.

SPECIES ACCOUNT: *Hamiota australis* (Southern sandshell)

Species Taxonomic and Listing Information

Listing Status: Threatened; October 10, 2012; Southeast Region (R4) (USFWS 2012)

Physical Description

The southern sandshell (Hamiota australis, Simpson 1900) is a medium sized freshwater mussel. The southern sandshell is elliptical in shape and reaches about 83 mm (2.3 in.) in length. Its shell is smooth and shiny, and greenish in color in young specimens, becoming dark greenish brown to black with age, with many variable green rays. The shell interior is bluish white and iridescent. Sexual dimorphism is present as a slight inflation of the posterioventral shell margin of females (Williams and Butler 1994, p. 97; Williams et al. 2008, p. 337). (USFWS 2012)

Taxonomy

The southern sandshell (Hamiota australis) was originally described by C. T. Simpson (1900) as Lampsilis australis. Heard (1975), however, designated it as a species of Villosa. It was placed in the genus Hamiota by Roe and Hartfield (2005, pp. 1–3), who confirmed earlier published suggestions by Fuller and Bereza (1973, p. 53) and O'Brien and Brim Box (1999, pp. 135– 136) that this species and three others of the genus Lampsilis represent a distinct genus. This separation from other Lampsilis is supported genetically (Roe et al. 2001, p. 2230). (USFWS 2012)

Historical Range

This species is known from the Escambia River drainage in Alabama, and the Yellow and Choctawhatchee River drainages in Alabama and Florida (Williams et al. 2008, p. 338). (USFWs 2012)

Current Range

The species is currently known to occur in Burnt corn creek, Murder Creek, Jordan Creek, Conecuh River, Patsaliga Creek, Yellow River, Shoal River, Pond Creek, Yellow River, Five Runs Creek, Bruce Creek, West Sandy Creek, Choctawhatchee River, Wrights Creek, Choctawhatchee River, Pea River, Flat Creek, Eightmile Creek, Natural Bridge Creek, Corner Creek, Pea Creek, Double Bridges Creek, West Fork Choctawhatchee River, Sikes Creek, Pauls Creek, and East Fork Choctawhatchee River. (USFWS 2012)

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On October 10, 2012, the U.S. Fish and Wildlife Service designated critical habitat for southern sandshell (Hamiota australis), under the Endangered Species Act of 1973, as amended (77 FR 61663 - 61719).

Critical Habitat Designation

Critical habitat for the southern sandshell is GCM1: Lower Escambia River, GCM3: Patsaliga Creek, GCM4: Upper Escambia River, GCM5: Yellow River, GCM6: Choctawhatchee River and Lower Pea River, and GCM7: Upper Pea River.

Unit GCM1: Lower Escambia River Drainage, Florida and Alabama. Unit GCM1 encompasses 558 km (347 mi) of the lower Escambia River mainstem and 12 tributary streams in Escambia and Santa Rosa Counties, FL, and Escambia, Covington, Conecuh, and Butler Counties, AL. The unit consists of the main channel of the EscambiaConecuh River from the confluence of Spanish Mill Creek, Escambia and Santa Rosa counties, FL, upstream 204 km (127 mi) to the Point A Lake dam, Covington County, AL; Murder Creek from its confluence with the Conecuh River, Escambia County, AL, upstream 62 km (38 mi) to the confluence of Cane Creek, Conecuh County, AL; Burnt Corn Creek from its confluence with Murder Creek, Escambia County, AL, upstream 59 km (37 mi) to County Road 20, Conecuh County, AL; Jordan Creek from its confluence with Murder Creek, upstream 5.5 km (3.5 mi) to Interstate 65, Conecuh County, AL; Mill Creek from its confluence with Murder Creek upstream 2.5 km (1.5 mi) to the confluence of Sandy Creek, Conecuh County, AL; Sandy Creek from its confluence with Mill Creek upstream 5.5 km (3.5 mi) to County Road 29, Conecuh County, AL; Sepulga River from its confluence with the Conecuh River upstream 69 km (43 mi) to the confluence of Persimmon Creek, Conecuh County, AL; Bottle Creek from its confluence with the Sepulga River upstream 5.5 km (3.5 mi) to County Road 42, Conecuh County, AL; Persimmon Creek from its confluence with the Sepulga River, Conecuh County, upstream 36 km (22 mi) to the confluence of Mashy Creek, Butler County, AL; Panther Creek from its confluence with Persimmon Creek upstream 11 km (7 mi) to State Route 106, Butler County, AL; Pigeon Creek from its confluence with the Sepulga River, Conecuh and Covington Counties, upstream 89 km (55 mi) to the confluence of Three Run Creek, Butler County, AL; and Three Run Creek from its confluence with Pigeon Creek upstream 9 km (5.5 mi) to the confluence of Spring Creek, Butler County, AL. Unit GCM1 is within the geographical area occupied at the time of listing (2012) for the round ebonyshell, southern kidneyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Escambia River system is within the species' historical range, and we consider it essential to the southern kidneyshell's conservation due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. The unit currently supports populations of round ebonyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, cooccur with these five species. A diverse fish fauna, including potential fish host(s) for the fuzzy pigtoe, are known from the Escambia River drainage, indicating the potential presence of PCE 5. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to two upstream impoundments. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM3: Patsaliga Creek Drainage, Alabama. Unit GCM3 encompasses 149 km (92 mi) of Patsaliga Creek and two tributary streams in Covington, Crenshaw, and Pike Counties, AL, within the Escambia River basin. The unit consists of the Patsaliga Creek mainstem from its confluence with Point A Lake at County Road 59, Covington County, AL, upstream 108 km (67 mi) to Crenshaw County Road 66-Pike County Road 1 (the creek is the county boundary), AL; Little Patsaliga Creek from its confluence with Patsaliga Creek upstream 28 km (17 mi) to Mary Daniel Road, Crenshaw County, AL; and Olustee Creek from its confluence with Patsaliga Creek upstream 12 km (8 mi) to County Road 5, Pike County, AL. Unit GCM3 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Patsaliga Creek system is within the species' historic range. We consider it essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the Patsaliga Creek drainage, indicating the potential presence of PCE 5. Prior to construction of the Point A Lake and Gantt Lake dams in 1923, Patsaliga Creek drained directly to the Conecuh River main channel. It now empties into Point A Lake and is effectively isolated from the main channel by the dams. The dams are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM4: Upper Escambia River Drainage, Alabama. Unit GCM4 encompasses 137 km (85 mi) of the Conecuh River mainstem and two tributary streams in Covington, Crenshaw, Pike, and Bullock Counties, AL, within the Escambia River drainage. The unit consists of the Conecuh River from its confluence with Gantt Lake reservoir at the Covington-Crenshaw County line upstream 126 km (78 mi) to County Road 8, Bullock County, AL; Beeman Creek from its confluence with the Conecuh River upstream 6.5 km (4 mi) to the confluence of Mill Creek, Pike County, AL; and Mill Creek from its confluence with Beeman Creek, upstream 4.5 km (3 mi) to County Road 13, Pike County, AL. Unit GCM4 is is within the geographical area occupied at the time of listing (2012) Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Conecuh River is within the species' historic range, and we consider it to be essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species requiring similar PCEs co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the upper Escambia River drainage, indicating the potential presence of PCE 5. The Point A Lake and Gantt Lake dams on the Conecuh River mainstem are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM5: Yellow River Drainage, Florida and Alabama. Unit GCM5 encompasses 247 km (153 mi) of the Yellow River mainstem, the Shoal River mainstem, and three tributary streams in Santa Rosa, Okaloosa, and Walton Counties, FL, and Covington County, AL. The unit consists of the Yellow River from the confluence of Weaver River (a tributary located 0.9 km (0.6 mi), downstream of State Route 87), Santa Rosa County, FL, upstream 157 km (97 mi) to County Road 42, Covington County, AL; the Shoal River from its confluence with the Yellow River, Okaloosa County, FL, upstream 51 km (32 mi) to the confluence of Mossy Head Branch, Walton County, FL; Pond Creek from its confluence with Shoal River, Okaloosa County, FL, upstream 24 km (15 mi) to the confluence of Fleming Creek, Walton County, FL; and Five Runs Creek from its confluence with the Yellow River upstream 15 km (9.5 mi) to County Road 31, Covington County, AL. Unit GCM5 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell was known from the Yellow River drainage; however, its occurrence in the basin is based on the collection of one specimen in 1919 from Hollis Creek in Alabama. We believe this single, historical record is not sufficient to consider this unit as essential to the conservation of the southern kidneyshell. Therefore, we are not designating Unit GCM5 as critical habitat for the southern kidneyshell at this time. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna are known from the Yellow River drainage, indicating the potential presence of PCE 5.

Unit GCM6: Choctawhatchee River and Lower Pea River Drainages, Florida and Alabama. Unit GCM6 encompasses 897 km (557 mi) of the Choctawhatchee River mainstem, the lower Pea River mainstem, and 29 tributary streams in Walton, Washington, Bay, Holmes, and Jackson Counties, FL, and Geneva, Coffee, Dale, Houston, Henry, Pike, and Barbour Counties, AL. The unit consists of the Choctawhatchee River from the confluence of Pine Log Creek, Walton County, FL, upstream 200 km (125 mi) to the point the river splits into the West Fork Choctawhatchee and East Fork Choctawhatchee rivers, Barbour County, AL; Pine Log Creek from its confluence with the Choctawhatchee River, Walton County, upstream 19 km (12 mi) to the confluence of Ditch Branch, Washington and Bay Counties, FL; an unnamed channel forming Cowford Island from its downstream confluence with the Choctawhatchee River upstream 3 km (2 mi) to its upstream confluence with the river, Washington County, FL; Crews Lake from its western terminus 1.5 km (1 mi) to its eastern terminus, Washington County, FL (Crews Lake is a relic channel southwest of Cowford Island, and is disconnected from the Cowford Island channel, except during high flows); Holmes Creek from its confluence with the Choctawhatchee River, Washington County, FL, upstream 98 km (61 mi) to County Road 4, Geneva County, AL; Alligator Creek from its confluence with Holmes Creek upstream 6.5 km (4 mi) to County Road 166, Washington County, FL; Bruce Creek from its confluence with the Choctawhatchee River upstream 25 km (16 mi) to the confluence of an unnamed tributary, Walton County, FL; Sandy Creek from its confluence with the Choctawhatchee River, Walton County, FL, upstream 30 km (18 mi) to the confluence of West Sandy Creek, Holmes and Walton County, FL; Blue Creek from its confluence with Sandy Creek, upstream 7 km (4.5 mi) to the confluence of Goose Branch, Holmes County, FL; West Sandy Creek from its confluence with Sandy Creek, upstream 5.5 km (3.5 mi) to the confluence of an unnamed tributary, Walton County, FL; Wrights Creek from its confluence with the Choctawhatchee River, Holmes County, FL, upstream 43 km (27 mi) to County Road 4, Geneva County, AL; Tenmile Creek from its confluence with Wrights Creek upstream 6 km (3.5 mi) to the confluence of Rice Machine Branch, Holmes County, FL; West Pittman Creek from its confluence with the Choctawhatchee River upstream 6.5 km (4 mi) to Fowler Branch, Holmes County, FL; East Pittman Creek from its confluence with the Choctawhatchee River upstream 4.5 km (3 mi) to County Road 179, Holmes County, FL; Parrot Creek from its confluence with the Choctawhatchee River upstream 6 km (4 mi) to Tommy Lane, Holmes County, FL; the Pea River from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 91 km (57 mi) to the Elba Dam, Coffee County, AL; Limestone Creek from its confluence with the Pea River upstream 8.5 km (5 mi) to Woods Road, Walton County, FL; Flat Creek from the Pea River upstream 17 km (10 mi) to the confluence of Panther Creek, Geneva County, AL; Eightmile Creek from its confluence with Flat Creek, Geneva County, AL, upstream 15 km (9 mi) to the confluence of Dry Branch (first tributary upstream of County Road 181), Walton County, FL; Corner Creek from its confluence with Eightmile Creek upstream 5 km (3 mi) to State Route 54, Geneva County, AL; Natural Bridge Creek from its confluence with Eightmile Creek Geneva County, AL, upstream, 4 km (2.5 mi) to the Covington-Geneva County line, AL; Double Bridges Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 46 km (29 mi) to the confluence of Blanket Creek, Coffee County, AL; Claybank Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 22 km (14 mi) to the Fort Rucker military reservation southern boundary, Dale County, AL; Claybank Creek from the Fort Rucker military reservation northern boundary, upstream 6 km (4 mi) to County Road 36, Dale County, AL; Steep Head Creek from the Fort Rucker military reservation western boundary, upstream 4 km (2.5 mi) to County Road 156, Coffee County, AL; Hurricane Creek from its confluence with the Choctawhatchee River upstream 14 km (8.5 mi) to State Route 52, Geneva County, AL; Little Choctawhatchee River from its confluence with the Choctawhatchee River, Dale and Houston Counties upstream 20 km (13 mi) to the confluence of Newton Creek, Houston County, AL; Panther Creek from its confluence with the Little Choctawhatchee River, upstream 4.5 km (2.5 mi) to the confluence of Gilley Mill Branch, Houston County, AL; Bear Creek from its confluence with the Little Choctawhatchee River, upstream 5.5 km (3.5 mi) to County Road 40 (Fortner Street), Houston County, AL; West Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 54 km (33 mi) to the fork of Paul’s Creek and Lindsey Creek, Barbour County, AL; Judy Creek from its confluence with West Fork Choctawhatchee River upstream 17 km (11 mi) to County Road 13, Dale County, AL; Sikes Creek from its confluence with West Fork Choctawhatchee River, Dale County, AL, upstream 8.5 km (5.5 mi) to State Route 10, Barbour County, AL; Paul’s Creek from its confluence with West Fork Choctawhatchee River upstream 7 km (4.5 mi) to one mile upstream of County Road 20, Barbour County, AL; Lindsey Creek from its confluence with West Fork Choctawhatchee River upstream 14 km (8.5 mi) to the confluence of an unnamed tributary, Barbour County, AL; an unnamed tributary to Lindsey Creek from its confluence with Lindsey Creek upstream 2.5 km (1.5 mi) to 1.0 mile upstream of County Road 53, Barbour County, AL; and East Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 71 km (44 mi) to County Road 71, Barbour County, AL. Unit GCM6 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the Choctawhatchee River, including a potential fish host for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. Not included in this unit are two oxbow lakes now disconnected from the Choctawhatchee River main channel in Washington County, Florida. Horseshoe Lake has a record of southern kidneyshell from 1932, and Crawford Lake has records of Choctaw bean and tapered pigtoe from 1934. It is possible these oxbow lakes had some connection to the main channel when the collections were made over 75 years ago. The three species are not currently known to occur in Horseshoe or Crawford lakes, and we do not consider them essential to the conservation of the southern kidneyshell, Choctaw bean, or tapered pigtoe. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to the Elba Dam on the Pea River mainstem. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM7: Upper Pea River Drainage, Alabama. Unit GCM7 encompasses 234 km (145 mi) of the upper Pea River mainstem and six tributary streams in Coffee, Dale, Pike, Barbour, and Bullock Counties, AL. This unit is within the Choctawhatchee River basin and includes the stream segments upstream of the Elba Dam. The unit consists of the Pea River from the Elba Dam, Coffee County, upstream 123 km (76 mi) to State Route 239, Bullock and Barbour Counties, AL; Whitewater Creek from its confluence with the Pea River, Coffee County upstream 45 km (28 mi) to the confluence of Walnut Creek, Pike County, AL; Walnut Creek from its confluence with Whitewater Creek upstream 14 km (9 mi) to County Road 26, Pike County, AL; Big Creek (Coffee County) from its confluence with Whitewater Creek, Coffee County, upstream 30 km (18 mi) to the confluence of Smart Branch, Pike County, AL; Big Creek (Barbour County) from its confluence with the Pea River upstream 10 km (6 mi) to the confluence of Sand Creek, Barbour County, AL; Pea Creek from its confluence with the Pea River upstream 6 km (4 mi) to the confluence of Hurricane Creek, Barbour County, AL; and Big Sandy Creek from its confluence with the Pea River upstream 6.5 km (4 mi) to County Road 14, Bullock County, AL. Unit GCM7 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the upper Pea River, including potential fish host(s) for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. The Elba Dam on the Pea River mainstem is a barrier to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological feature includes the absence of potential host fishes.

Primary Constituent Elements/Physical or Biological Features

Within critical habitat areas, the primary constituent elements of the physical or biological features essential to the conservation of the southern sandshell consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to this mussel and its habitat are pervasive and common in all of the units that are designated as critical habitat. These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas designated as critical habitat are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species (NatureServe 2015).

Reproduction Narrative

Adult: It is a long-term brooder, and females are gravid from late summer or autumn to the following spring (Williams et al. 2008, p. 338). The southern sandshell is one of only four species that produce a superconglutinate to attract a host. This requires clear water to attract a sight-feeding fish. The superconglutinate mimics the shape, coloration, and movement of a fish and is produced by the female mussel to hold all glochidia (larval mussels) from one year’s reproductive effort (Haag et al. 1995, p. 472). Although the fish host for the southern sandshell has not been identified, it likely uses predatory sunfishes such as basses, like other Hamiota species (Haag et al. 1995, p. 475; O’Brien and Brim Box 1999, p. 134; Blalock-Herod et al. 2002, p. 1885). (USFWS 2012) The superconglutinate contains approximately 1700 glochidia (Blalock-Herod et al., 2002). (NatureServe 2015)

Geographic or Habitat Restraints or Barriers

Adult: Dams (see dispersal/migration narrative

Spatial Arrangements of the Population

Adult: Linear (USFWS 2012)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS 2012)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: The southern sandshell is typically found in small creeks and rivers in stable substrates of sand or mixtures of sand and fine gravel, with slow to moderate current. The habitat is linear in nature. Primary constituent elements include (1) Geomorphically stable stream and river channels and banks (2) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae (3) A hydrologic flow regime necessary to maintain benthic habitats and connectivity of rivers with the floodplain (4) Water quality, including temperature (not greater than 32 oC), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 mg/L). (USFWS 2012) The environmental specificity of this species is narrow, as this species is thought to require clean waters and stable substrates.

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low - moderate (inferred from NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Fish host (NatureServe 2015)

Dispersal/Migration Narrative

Adult: By blocking fish movement, the dams may prevent gene exchange between upstream and downstream mussel populations. (USFWS 2012) Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate although some passive movement downstream may occur during high flows. Dispersal occurs while the glochidia are encysted on their host (probably a fish) (NatureServe 2015).

Population Information and Trends

Population Trends:

Declining (USFWS 2012)

Number of Populations:

21 - 80 (NatureServe 2014)

Population Size:

10,000 - 100,000 (NatureServe 2015)

Additional Population-level Information:

Southern Sandshell records are known from the Escambia River basin in Alabama and the Yellow and Choctawhatchee River basins in Alabama and Florida (Fig. 8). Overall, the species is maintaining populations in the Yellow River basin and in some high-quality tributaries in the Choctawhatchee River basin. However, it is likely declining elsewhere in its historical range. The species is occasionally found in lightly disturbed habitats, but only occurs in high abundance in high-quality stream systems. Southern Sandshell current (2000–2021) occurrences are discussed below and summarized by subbasin in Appendix A. Escambia River Basin A small population exists in the Lower Conecuh subbasin, where 20 live individuals have been observed since 2000. It has not been detected recently within the Sepulga, Patsaliga, and Upper Conecuh subbasins; however, too few surveys have been conducted in these reaches to fully assess its status in this portion of its range. Overall, the species appears to be declining in the Escambia River basin. Yellow River Basin Presently, the species is maintaining populations in the Yellow River basin, but it is relatively uncommon. A total of 135 live individuals were observed in recent surveys. One live individual was detected in the Five Runs Creek stream system in Alabama, indicating a small population exists within the tributary system. Choctawhatchee River Basin A total of 690 live individuals were detected in recent surveys; most (n = 450) were observed in the Lower Choctawhatchee subbasin in Florida. The species is abundant in a few high-quality tributaries, including Bruce Creek (FL), Eightmile Creek (AL), and upper Pea River (AL), but is relatively uncommon elsewhere in its range. Overall, the Southern Sandshell remains widespread in the basin but is likely extirpated in some historical locations (USFWS, 2022).

Population Narrative:

The southern sandshell persists in its historic range; however, its range is fragmented and numbers appear to be declining (Williams et al. 2008, p. 338). (USFWS 2012) The range of this species is 400 - 2,000 square miles, with 21 - 80 occurrences, and a population size of 10,000 - 100,000 individuals. Only 1 - 3 of these occurrences have good viability/integrity. This species is highly to moderately vulnerable, as freshwater mussels are inherently vulnerable to threats from siltation, pollution, eutrophication, channelization, impoundment, collection, drought and water withdrawal, competition from invasive non-native mussels, and changes to larval host fish populations. In addition, this species is one of a few mussels that produces a superconglutinate lure to attract host fish and therefore relies upon clear water to complete its life cycle. (NatureServe 2015)

Threats and Stressors

Stressor: Pollution (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Nonpoint-source pollution from land surface runoff originates from virtually all land use activities and includes sediments, fertilizer, herbicide and pesticide residues; animal wastes; septic tank leakage and gray water discharge; and oils and greases. Current activities and land uses that can negatively affect populations of these eight mussels include unpaved road

crossings, improper silviculture and agriculture practices, highway construction, housing developments, pipeline crossings, and cattle grazing. Land surface runoff also contributes nutrients (for example, nitrogen and phosphorus from fertilizers, sewage, and animal manure) to rivers and streams, causing them to become eutrophic. Excessive nutrient input stimulates excessive plant growth (algae, periphyton attached algae, and nuisance plants). This enhanced plant growth can cause dense mats of filamentous algae that can expose juvenile mussels to entrainment or predation and be detrimental to the survival of juvenile mussels (Hartfield and Hartfield 1996, p. 373). Excessive plant growth can also reduce dissolved oxygen in the water when dead plant material decomposes. Because of their sedentary characteristics, mussels are extremely vulnerable to toxic effluents (Sheehan et al. 1989, pp. 139–140; Goudreau et al. 1993, pp. 216–227; Newton 2003, p. 2543). (USFWS 2012)

Stressor: Sedimentation (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Sedimentation is one of the most significant pollution problems for aquatic organisms (Williams and Butler 1994, p. 55), and has been determined to be a major factor in mussel declines (Ellis 1936, pp. 39–40). Impacts resulting from sediments have been noted for many components of aquatic communities. For example, sediments have been shown to abrade or suffocate periphyton (organisms attached to underwater surfaces); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters 1995, pp. 173– 175). Heavy sediment loads can destroy mussel habitat, resulting in a corresponding shift in mussel fauna (Brim Box and Mossa 1999, p. 100). Excessive sedimentation can lead to rapid changes in stream channel position, channel shape, and bed elevation (Brim Box and Mossa 1999, p. 102). Sedimentation has also been shown to impair the filter feeding ability of mussels. When in high silt environments, mussels may keep their valves closed more often, resulting in reduced feeding activity (Ellis 1936, p. 30), and high amounts of suspended sediments can dilute their food source (Dennis 1984, p. 212). Increased turbidity from suspended sediment can reduce or eliminate juvenile mussel recruitment (Negus 1966, p. 525; Brim Box and Mossa 1999, pp. 101–102). Many mussel species use visual cues to attract host fishes; such a reproductive strategy depends on clear water. Potential sediment sources within a watershed include virtually any activity that disturbs the land surface. Current sources of sand, silt, and other sediment accumulation in south-central Alabama and western Florida stream channels include unpaved road runoff, agricultural lands, timber harvest, livestock grazing, and construction and other development activities (Williams and Butler 1994, p. 55; Bennett 2002, p. 5 and references therein; Hoehn 1998, pp. 46–47 and references therein). (USFWS 2012)

Stressor: Channel instability (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Mussels require stable stream and river habitats and activities that cause channel instability can negatively impact their populations. Activities such sand and gravel mining, the removal of large woody material, off-road vehicles use, and land use changes are known to cause channel destabilization. Activities that destabilize stream beds and channels can result in drastic alterations to stream geomorphology and consequently to the stream's ecosystem. Instream

gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, p. 10; Hartfield 1993, pp. 138–139). Poorly located or inadequately designed mines in the flood plain can have similar effects and result in alterations to streams channels (Mossa and Coley, 2004, p. 2). Land use activities such as land clearing and development can cause channel instability by accelerating storm water runoff into streams. (USFWS 2012)

Stressor: Impoundments (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The damming of rivers has been a major factor contributing to the demise of freshwater mussels (Bogan 1993, p. 604). Dams eliminate or reduce river flow within impounded areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, affect normal flood patterns, and block upstream and downstream movement of mussels and their host fishes (Bogan 1993, p. 604; Vaughn and Taylor 1999, pp. 915–917; Watters 1999, pp. 261–264; McAllister et al. 2000, p. iii; Marcinek et al. 2005, pp. 20–21). Downstream of dams, mollusk declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels, water temperatures, and changes in resident fish assemblages (Williams et al. 1993, p. 7; Neves et al. 1997, pp. 63–64; Watters 1999, pp. 261– 264; Marcinek et al. 2005, pp. 20–21). (USFWS 2012)

Stressor: Stochastic events (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may contribute to the further decline of mussel populations suffering the effects of other threats. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin et al. 2002, p. 6074; Golladay et al. 2004, p. 504; Cook et al. 2004, p. 1015). Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in stream temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions. (USFWS 2012)

Stressor: Small, isolated populations (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153). (USFWS 2012)

Stressor: Nonindigenous species (USFWS 2012)
Exposure:

Response:
Consequence:
Narrative: The Asian clam (Corbicula fluminea) has been introduced to the drainages and may be adversely affecting these eight mussels through direct competition for space and resources. Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles, and may actively disturb sediments, reducing habitable space for juvenile native mussels, or displacing them downstream (Strayer 1999, p. 82; Yeager et al. 2000, pp. 255–256). The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations. Biologists working in the Florida portions of these drainages have observed a correlation between the increase in flathead catfish numbers and a decrease in numbers of other native fish species, particularly of bullhead catfish (Ameiurus sp.) and redbreast sunfish (Lepomis auritus) (Strickland 2010 pers. comm.). (USFWS 2012)

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.
- Conservation activities have been limited to working with landowners in west Alabama and south Florida to limit the effects of agricultural practices on populations (NatureServe 2015).

Conservation Measures and Best Management Practices:
- RECOMMENDED FUTURE ACTIVITIES These seven species do not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities, which are included below. Recovery Activities a. Encourage the protection and establishment of wide riparian buffer zones along all streams containing or draining into the historical ranges of these species. Buffers of at least 300 feet in width and consisting of native forest are considered the most protective and effective. A greater width may be necessary to effectively buffer storm water runoff from urban and suburban lands, cultivated fields, and timber harvest operations. b. Restore and increase in-stream habitat and stream connectivity through conservation actions, including but not limited to removing artificial fish migration barriers, bank stabilization, riparian buffer maintenance or augmentation, improving water quality downstream of impoundments, and adherence to BMPs. c. Work with state and federal agencies and private organizations to promote land and water stewardship awareness (e.g., Soil and Water Conservation Districts, Natural Resource Conservation Service (NRCS), State Forestry Commissions, private industry groups, environmental groups, etc.). d. Develop programs and outreach materials to increase public awareness of these species and explain the benefits of protecting stream ecosystems. Monitoring and Research Activities a. Conduct status survey for Round Ebonyshell in the Conecuh River and document habitat conditions. b. Conduct surveys in under sampled portions of their ranges to examine the species’ status and habitat conditions. c. Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. d. Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, and age-specific survival. e. Use eDNA as a detection tool to provide up-to-date

distributional information, especially for rare or cryptic species like Southern Kidneyshell. Use assays to confirm presence in historical reaches and detect previously unknown populations. f. Conduct long-term monitoring studies of stream thermal regimes, especially during summer low flow conditions. g. Prepare a comprehensive threats assessment that identifies and maps existing and potential threats within the watersheds and identifies activities or practices that may affect the seven mussels or their habitats. Use the assessment to develop SSAs and recovery plans for the species. h. Model future precipitation, temperature, and flow scenarios in the basins to examine the impacts of climate change and consumptive uses. Use the assessment to develop SSAs and recovery plans for the species. i. Model future sea level and flow scenarios to analyze the effects of saltwater encroachment in the lower mainstems during high tide and storm surge events. Use the assessment to develop SSAs and recovery plans for the species. j. Research important life-history traits, such as host fish use, growth, longevity, age at maturity, and fecundity, and incorporate the results into management and protection actions. All partners should be aware of research efforts and results to facilitate the immediate application of results. k. Determine temperature and contaminant sensitivity for each life-stage, and develop recommendations for EPA and state water quality criteria to protect and enhance habitat. l. Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans. m. Study the life history and identify the host fish of the Southern Sandshell, Choctaw Bean, and Round Ebonyshell (USFWS, 2022).

References

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 FR 61663 - 61719 (October, 10, 2012).

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016). USFWS. 2022. 5-YEAR REVIEW Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum Status Review: Summary and Evaluation. Southeast Region. Florida

Ecological Services Field Office. Panama City, Florida. 54 pp.

USFWS. 2012. Endangered and Threatened Wildlife and Plants

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 24, 2016).

USFWS. 2022. 5-YEAR REVIEW Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

SPECIES ACCOUNT: *Hemistena lata* (Cracking pearlymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 09/28/1989, 06/14/2001; Southeast Region (R4) (USFWS, 2016)

Physical Description

This freshwater mussel has a thin, medium-size, elongated, and slightly inflated shell (Bogan and Parmalee 1983). The shell's outer surface (periostracum) is brownish green to brown and often has broken dark green rays. The nacre is pale bluish to purple (USFWS 1991).

Taxonomy

The cracking pearlymussel was initially described by Rafinesque (1820) (USFWS 1991). This species is in a monotypic genus closely related to the genus Elliptio (NatureServe 2015).

Historical Range

This species historically occurred in the Ohio, Cumberland, and Tennessee River systems (Bogan and Parmalee 1983, pp. 44–45, Service 1991a, pp. 2–5). Historical records exist from the Tennessee River near the confluence of the French Broad and Holston Rivers (Parmalee and Bogan 1998, p. 122). (USFWS 2007).

Current Range

It is extirpated throughout much of its range. It now survives at a few shoals in the Clinch and Powell Rivers in Tennessee and Virginia (Bogan and Parmalee 1983, p. 45; Neves 1991, p. 277). It possibly survives in the Green River in Kentucky and in the Tennessee River, below Pickwick Dam, in Tennessee (Service 1991a) (USFWS 2007).

Critical Habitat Designated

No;

Life History

Feeding Narrative

<u>Adult:</u> Specific food habits of the cracking pearlymussel are unknown, but it likely feeds on food items similar to those consumed by other freshwater mussels. Freshwater mussels are known to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924), which they filter out of the water (USFWS 1991).

Reproduction Narrative

<u>Adult:</u> The cracking pearlymussel's reproductive biology is unknown, but it probably reproduces like other freshwater mussels. Males release sperm into the water column, which is taken in by females during feeding a respiration. The fertilized eggs are retained in the gills until the larvae fully develop. Gravid female cracking pearlymussels have been observed during mid-May (Ortmann 1915). When the glochidia are released into the water, they attach and encyst on the gills or fins of a fish host. The species of host fish utilized by the cracking pearlymussel and the habitat utilized by the juveniles are unknown USFWS 1991).

Geographic or Habitat Restraints or Barriers

Adult: Dams, deep water, lack of lotic connections (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2011)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits cobble, gravel, sand, and sometimes mud substrate in medium to large rivers of the Ohio River basin (USFWS 2011). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low - moderate (inferred from NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

Declining (USFWS 2011)

Number of Populations:

1 - 5 (NatureServe 2015)

Population Size:

50 - 1,000 (NatureServe 2015)

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

The cracking pearlymussel is still found in the Clinch River and Elk River, but these populations are declining as a result of coal fines (Nicholson 2006, pers. comm.). The species is thought to be extirpated or is thought to occur in numbers too low to maintain viability from other streams within its historic range. No information is available concerning the genetics or genetic trends of this species (USFWS 2011). The range extent of this species is 40 - 100 square miles, with 1 - 5 occurrences. Estimated population size is 50 - 1000 individuals, with 1 - 3 occurrences having good viability/integrity. This species is highly vulnerable, as all populations are geographically isolated from one another restricting natural interchange of genetic material and all have extremely small population size with questionable viability at best (the Clinch River population being an exception) (USFWS, 1991). (NatureServe 2015).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 1990)
Exposure:
Response:
Consequence:
Narrative: Impoundments, siltation and pollution leading to water quality and habitat deterioration. Inadequate sewage treatment, coal mining, oil and gas drilling and poor land-use practices. The Powell River watershed was mined extensively for coal, and coal mining impacts are still present, especially in the upper reaches. The lower reaches of the Powell River have large deposits of coal fines and silt. The Clinch River has been adversely affected by pollution and land use practices along the river have contributed to the decline of water quality and loss of mussel populations. It has also experienced some impacts from coal mining. Toxic spills have historically produced mussel kills in the river. Although suitable habitat exists in the Elk River, cold water releases from Tims Ford Reservoir and pollution from unknown sources in the lower Elk River have impacted mussel fauna and reduced density (USFWS, 1990)

Stressor: Hydroelectric dam operation (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Coldwater releases and peaking hydropower operation is reported to affect mussel populations in the Elk and Cumberland Rivers (USFWS, 2011).

Stressor: Small populations (USFWS, 2011)
Exposure:
Response:
Consequence:

Narrative: The known populations of cracking pearlymussel are small and genetically isolated. Population numbers in the Elk River, Powell River, Tennessee River, and Green River are likely below those needed to maintain long-term viability (USFWS, 2011).

Recovery

Reclassification Criteria:
1. Reestablish/discover five viable populations (USFWS 2007).

2. Ensure that one naturally produced year class exists within each population (USFWS 2007).

3. Determine if recovery actions have been successful, as determined by an increase in population density and/or an increase in length of river inhabited (USFWS 2007).

4. Ensure there are no foreseeable threats to the continued existence of any population (USFWS 2007).

Delisting Criteria:
1. Through protection of existing populations and successful establishment of reintroduced populations or the discovery of additional populations, a total of eight distinct viable populations exist. These populations must be separated to the extent that it is unlikely that a single event would eliminate or significantly reduce more than one of these populations. The populations shall be distributed throughout the Ohio River basin as follows: two in the upper Tennessee River system, two in the middle to lower Tennessee River system, one in the Cumberland River system, one in a Kentucky tributary to the Ohio River other than the Cumberland River, and two in the Wabash River system (USFWS 2011).

2. Two distinct naturally reproduced year classes exist within each of the eight populations. Both year classes must have been produced within 10 years, and one year class within 5 years, of the recovery date. Within 1 year of the recovery date, gravid females of the species and its host fish must be present in each river (USFWS 2011).

3. Studies of the mussel’s biological and ecological requirements have been completed, and recovery measures developed and implemented from these studies have been successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the eight populations (USFWS 2011).

4. No foreseeable threats exist that would likely threaten the survival of any of these eight populations (USFWS 2011).

5. Where habitat has been degraded, noticeable improvements in water and substratum quality have occurred (USFWS 2011).

Recovery Actions:
- Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat (USFWS 2011).

- Meet with appropriate Federal, State, and local government officials and regional and local planners to inform them of our plans to attempt recovery and request their support (USFWS 2011).
- Meet with local business, mining, logging, farming, and/or industry interests and elicit their support in implementing protective actions (USFWS 2011).
- Develop an educational program using such items as slide/tape shows, brochures, etc. Present this material to business groups, civic groups, youth groups, schools, church organizations, etc (USFWS 2011).
- Consider and, if determined necessary, use land acquisition as a means of protecting present and reintroduced populations (USFWS 2011).
- Conduct life history research on the species to include such factors as reproduction, food habits, age and growth, and mortality rates (USFWS 2011).
- Characterize the species' habitat requirements (relevant physical, biological, and chemical components) for all life history stages (USFWS 2011).
- Determine present and foreseeable threats to the species (USFWS 2011).
- Investigate the relationships with nonnative bivalves (USFWS 2011).
- Based on the biological data and threat analysis, investigate the need for management, including habitat improvement. Implement management, if needed, to secure viable populations (USFWS 2011).
- Determine number of individuals required to maintain a viable population (USFWS 2011).
- Search for additional populations and/or habitat suitable for reintroduction efforts (USFWS 2011).
- Determine the need, appropriateness, and feasibility of augmenting and expanding existing populations (USFWS 2011).
- Develop a successful technique for reestablishing and augmenting populations (USFWS 2011).
- Coordinate with appropriate Federal and State agency personnel, local governments, and interested parties to identify streams suitable for augmentation and reintroduction and those most easily protected from further threats (USFWS 2011).
- Reintroduce the species into its historic range and evaluate success (USFWS 2011).
- Implement the same protective measures for introduced populations that were outlined for established populations (USFWS 2011).
- Develop and implement cryogenic techniques to preserve the species' genetic material until such time as conditions are suitable for reintroduction (USFWS 2011).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as newly discovered, introduced, or expanding populations (USFWS 2011).
- Annually assess overall success of the recovery program and recommend action (modify recovery objectives, delist, continue to protect, implement new measures, or other studies, etc.) (USFWS 2011).
- Develop propagation technology for the cracking pearlymussel and birdwing pearlymussel. Continue propagation of the dromedary pearlymussel for augmentation of extant populations and reestablishment of new populations (USFWS 2011).
- Augment existing populations to ensure viability (USFWS 2011).
- Reestablish populations into suitable habitat in other streams within the species' historic ranges (USFWS 2011).

- Work with other Federal agencies, State agencies, individuals, and other partners to restore, maintain, and protect suitable habitat in the rivers containing extant and reestablished populations of these species (USFWS 2011).
- Continue to explore the feasibility of cryogenic preservation of gametes and/or larvae of the birdwing pearlymussel, dromedary pearlymussel, and cracking pearlymussel. Advances in cryopreservation technology since previous efforts with mussels may now make this technique of protecting genetic material feasible (USFWS 2011).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions The following actions are generally ordered on priority, with the higher priorit actions listed towards the top. Conduct additional studies to investigate the cause of the mussel die offs in the Clinch river. Refine propagation techniques and conduct additional fish host studies to support population reintroductions and augmentations. Continue efforts to monitor and expand the population in the Clinch river upstream and downstream of its current distribution. Reassess the need to augment these populations by reintroducing the species to currently unoccupied reaches of both rivers. Continue efforts to monitor and expand the population in the Elk River upstream of its current distribution. The Elk river becomes impounded by backwaters of Wheeler reservoir a short distance downstream of the TN/AL border so it is unlikely that its current downstream distribution can be expanded. Take appropriate actions to eliminate or greatly diminish threats to this species in the Elk and Clinch rivers. Regulations that apply to non-point pollution need to be strictly enforced to prevent loss of these populations. Reintroduce and reestablish viable populations in other streams within the historical range that have suitable habitat and water quality. The Cumberlandian Region Mollusk Restoration Committee (2010) recommended the following as priority rivers for reintroduction: the Nolichucky River (TN), the Duck River ™, and the Big South Fork of the Cumberland River (KY, TN). The following were also identified as having potential for reintroductions: the Tennessee River main stem tailwaters (Wilson, AL and Pickwick Landing, TN), lower French Broad/Holston (TN), upper French Broad (TN, upper Holston (TN), and Buffalo (TN). Consider other potential reintroductions sites within the historical range of the species, such as the Green River. Augment the population in the Elk river through introduction of propagated juvenile (as recommended by the Cumberlandian Region Mollusk Restoration Committee (2010)). Continue to educate the public about water quality and freshwater mussels. (USFWS, 2019)

References

USFWS 2007. Endangered and Threatened Wildlife and Plants

Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461

USFWS 1991. Cracking Pearlymussel (Hemistena (=Lastena) lata) Recovery Plan. Atlanta, GA. 25 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 28, 2016).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March

28, 2016)

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee.

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee

U.S. Fish and Wildlife Service. 1990. Cracking Pearlymussel (Hemistena (=Lastena) lata) Recovery Plan. Atlanta, GA. 25 pp.

USFWS. 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]), Dromedary pearlymussel (Dromus dromas), Cracking pearlymussel (Hemistena lata)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Cookeville Ecological Services Field Office, Cookeville, Tennessee. 27 pp.

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office, Cookeville, Tennessee.

USFWS. 2019. Cracking Pearlymussel Hemistena lata (Rafinesque, 1820). 5-Year Review: Summary and Evaluation. 28 pp.

SPECIES ACCOUNT: *Lampsilis abrupta* (Pink mucket (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Endangered; June 14, 1976; Southeast Region (R4) (USFWS 1985)

Physical Description

The outward appearance of L. orbiculata is characterized by an elliptical, subovate, subquadrate shell attaining a size of approximately 105 mm long, 82 mm high, and 61 mm wide. The periostracum can be glossy in younger specimens or dull in old individuals. Color is yellow to yellowish or greenish brown with wide greenish rays present in younger specimens. The surface of the shell is smooth except for wide, relatively dark, concentric growth rests. Nacre coloration is generally pink or salmon, to solid, iridescent, silvery white (USFWS 1985).

Taxonomy

The earliest name which fits the description of L. orbiculata is by Say (1831) in his description of Unio abruptus. Unio abruptus is undoubtedly the proper description for L. orbiculata as reported by Binney (1858), Clarke (1982), and Bogan and Parmalee (1983) (USFWS 1985).

Historical Range

Historical records for L. orbiculata indicate this is strictly an Ohioan or Interior Basin species, found mainly in the Tennessee, Cumberland, and Ohio River drainage with occasional records from the Mississippi River drainage. Historically, L. orbiculata occurred in 25 river systems and was extremely widespread (USFWS 1985).

Current Range

Today, the species has been found living in the tailwaters of several dams in Tennessee, and there is a localized relict population in the Cumberland River, Smith Co., but all individuals appear very old. It is nearly gone from the upper and middle stretches of the Tennessee River with a stable population below Pickwick Landing Dam in Hardin Co. and populations in the Cumberland River are also localized while occasional individuals can be found in several small to medium-sized tributaries of large rivers including the Holston, French Broad, and upper Clinch Rivers (Parmalee and Bogan, 1998). In Missouri it is found in the St. Francis River and the Sac River; with specimens still found from the mouth of the Bourbeuse River to the mouth of the Meramec River with other populations (possibly historical) in the lower Big River, lower Meramec River, Little Black and lower Osage Rivers (Oesch, 1995). Tolin et al. (1987) report the upper free-flowing 3.5 miles of the Kanawha River and the mainstem of the Ohio River (at depth) at the West Virginia border still support populations. Populations appear stable but low in the Black, Oucahita, and Spring River, Arkansas (Harris et al., 1997). Most occurrences in Kentucky are represented by very few individuals where it occurs sporadically in the lower Ohio River to the Licking River (Cicerello and Schuster, 2003) (NatureServe 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: The adults are classified as detritivores while the immature form is parasitic (NatureServe 2015).

Reproduction Narrative

Adult: The life history of L. orbiculata is unknown; however it is probably similar to that of most naiades. Males produce sperm which are discharged into the surrounding water and dispersed by water currents. Females obtain these sperm during feeding and respiration (Stein, 1971). Fertilized eggs are retained in the posterior section of the outer gills, which are modified as brood pouches. L. orbiculata is a bradytictic species becoming gravid in august with females having glochidia in September which are released (discharged) the following year in June (Ortmann; 1912, 1919) (USFWS 1985). In laboratory studies by Barnhart et al. (1997), the following fish were identified as suitable glochidial hosts: largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieui), spotted bass (Micropterus punctulatus) and walleye (Stizostedion vitreum) (NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, deep water, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 1985)

Environmental Specificity

Adult: Moderate (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Freshwater mussels are benthic animals that usually remain buried in the substrate with only the most posterior margin of the shell and siphons exposed to the water column. L. orbiculata is found in medium to large rivers (20 m wide or greater) in habitats ranging from silt to boulders, rubble, gravel, and sand substrates (Hickman, 1937; Yokley, 1972; Buchanan, 1980; Clarke, 1982). L. orbiculata is most often associated with larger rivers (Ohio, Tennessee, and Cumberland Rivers) in moderate to fast-flowing water, at depths ranging from 0.5 to 8.0 m. Ortmann (1919) collected this species from riffles with strong currents as did Bogan and Parmalee (1983) (USFWS 1985). The environmental specificity of this species is moderate, as it appears to have adapted somewhat to existence in impounded sections of big rivers. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low - moderate (inferred from NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Dispersal by their large, vagile, habitat generalist host fishes-commonly found in reservoir, tailwater, and riverine habitats alike- may account for sporadic and sometimes highly disjunct occurrences of Pink Mucket individuals in non-riverine conditions and in streams long distances form known populations. (USFWS, 2018)

Population Information and Trends

Population Trends:

Declining (NatureServe 2015)

Number of Populations:

6 - 20 (NatureServe 2015)

Population Size:

2,500 - 100,000 (NatureServe 2015)

Population Narrative:

The range extent of this species is 400 - 2,000 square miles, with 6 - 20 occurrences. The estimated population size is 2,500 - 100,000 individuals with 4 - 12 occurrences having good viability/integrity. This species has declined by 30 - 50% (NatureServe 2015).

Threats and Stressors

Stressor: Erosion (USFWS, 1997)
Exposure:
Response:
Consequence:
Narrative: Erosion caused by strip mining, logging and farming adds silt to many rivers, which can clog the mussel’s feeding siphons and even bury it completely. Other threats include pollution from agricultural and industrial runoff. These chemicals and toxic metals become concentrated in the body tissues of such filter-feeding mussels as the pink mucket, eventually poisoning it to death (1997).

Stressor: Habitat destruction and modification (USFWS, 2015)
Exposure:

Response:
Consequence:
Narrative: Dams, reservoirs, and impoundments have flooded much of this mussel's habitat, and contributed directly to the extirpation of pink mucket populations in some streams and resulted in the highly fragmented habitat and isolated populations currently seen in the species. Large dams also affect the flow and water quality downstream (reduced temperature, oxygen, and flow, and bank and substrate instability and erosion), which continues to negatively affects pink mucket populations (USFWS, 2015).

Stressor: Pollution (USFWS, 1985)
Exposure:
Response:
Consequence:
Narrative: An increasing number of streams receive municipal, agricultural, and industrial waste discharges. The damage suffered varies according to a complex of interrelated factors, which include the characteristics of the receiving stream and the nature, magnitude, and frequency of the stresses being applied (USFWS, 1985).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. When two additional viable populations of L. orbiculata are found in any two rivers except the Tennessee, Cumberland, and Meramec Rivers. Both of these rivers will contain viable populations that are distributed such that a single event would be unlikely to eliminate L. orbiculata from the river system. Survey data must show at least five viable populations with each population having a minimum of two year classes between 4 and 10 years of age as evidence of reproduction (USFWS 1985).

2. Additional mussel sanctuaries are established or expanded in river systems which contain known concentrations of L. orbiculata (USFWS 1985).

3. An education program is established for the public with major emphasis towards commercial mussel fisherman (USFWS 1985).

4. The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (USFWS 1985).

Recovery Actions:
- Conduct population and habitat surveys for L. orbiculata (USFWS 1985).
- Preserve populations and presently used habitat of L. orbiculata (USFWS 1985).
- Develop education programs (USFWS 1985).
- Maintenance of flowing water conditions and suitable water quality. Location of element occurrences near municipal or industrial wastewater outfalls necessitates frequent monitoring of water quality in the vicinity (NatureServe 2015).

- Determine specific ecological requirements (minimum water flow required, substrate preferences, influences of water temperature and food quality on growth rates, etc.) of the mussel, as well as the effects of particular pollutants (NatureServe 2015).
- RECOMMENDATIONS FOR FUTURE ACTIONS: Priority Actions: 1) Prepare a species status assessment to evaluate the species status under the ESA and to help inform recovery planning prior to development of the next five-year review. Any revision would address the species' current range and the known status of its populations, while adding propagation technology as a recovery tool, and other actions and activities needed for recovery. a. Within the Recovery Plan, prepare a rangewide population restoration and monitoring plan for the species to guide managers on which populations and rivers to focus reintroduction and augmentation efforts. 2) Conduct a rangewide phylogenetic analysis to determine if distinct taxonomic or evolutionarily significant populations are evident and to guide managers in source population selection for reintroductions and augmentations. 3) Conduct habitat assessments in unoccupied streams and stream reaches to determine the feasibility of population restoration activities (e.g., lower Ouachita River, Louisiana). 4) Reintroduce populations in streams within its historical range in reaches that have suitable habitat and water quality conditions. This can be achieved through the propagation of juveniles and/or release of infected host fishes. For example, the following Cumberlandian Region streams were recommended by the Cumberlandian Region Mollusk Restoration Committee (CRMRC) (2010) for reintroduction: Tennessee River drainage - Nolichucky River, Tennessee; Duck River, Tennessee; Elk River, Alabama/f ennessee; Emory River, Tennessee; upper French Broad River, Tennessee; upper Holston River, Tennessee; and Hiwassee River, Tennessee; Cumberland River drainage - Cumberland River, Barkley Dam tailwaters, Kentucky; Rockcastle River, Kentucky; and Big South Fork, Tennessee/Kentucky. 5) Conduct a population genetics study that specifically provides information critical for maintaining adequate levels of genetic diversity, particularly as they relate to hatchery cultured individuals (e.g., population structure, gene flow, kinship; e.g., Eackles and King 2002). 6) Continue to augment and expand select extant populations through the propagation and subsequent growout of juveniles and/or release of infested host fishes. For example, the following Tennessee River streams were recommended by CRMRC (2010) for augmentation: upper Clinch River, Virginia/f ennessee; and Paint Rock River, Alabama (though the latter is a lower priority due to the potential for it not representing a true population; see section II.C.l). 7) Determine the degree of threats (e.g., from mining, pollutants, navigation activities) to extant populations, and devise a plan to address these threats. 8) Work with partners to solicit funding from various sources (e.g., Corps mitigation, Endangered Species Act Section 6) to fund propagation, reintroduction, and augmentation efforts. 9) Determine the conservation status of extant populations through periodic monitoring including a quantitative component that provides basic population size estimates and a sampling design specifically for searching for juveniles, thus facilitating the assessment of recruitment into a population. 10) Continue to work with FERC and other partners through the relicensing process in modifying the discharges of private dams to improve habitat conditions in tailwaters. 11) Continue to work with TVA, the Corps, and other partners in modifying non-private dam discharges to improve habitat conditions in tailwaters. 12) Continue to work with EPA and other partners to ensure that national water quality criteria for ammonia and other contaminants are protective of all life stages of the species. Other Actions: 1) Continue to refine propagation technology for laboratory culture, translocation methodologies (including streamside infestations), and population restoration activities. 2) Conduct population viability analyses and explore other aspects of demographics of significant extant

populations (e.g., recruitment and mortality rates, longevity, sex ratios). 3) Conduct studies to determine if hydraulic factors can affect species patchiness and potentially rareness in large river habitats (e.g., Newton et al. 2008) 4) Map stable substrate patches in large river habitats using hydraulic variables and GIS technology, and ground truth species use of these habitat patches. 5) Once stable habitat patches are identified, use models to: 1) predict patch extent and location spatially and temporally and 2) conduct threat assessments from particular stressors. 6) Monitor Zebra Mussel and other nonindigenous species that may pose a threat to its populations (USFWS, 2019).

References

USFWS 1985. Recovery Plan for the Pink Mucket Pearly Mussel Lampsilis orbiculata (Hildreth, 1828). U.S. Fish and Wildlife Service Atlanta, Georgia

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 28, 2016).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 28, 2016). USFWS. 2018. Pink Mucket. Lampsilis abrupta. 5-Year Review: Summary and Evaluation. 68 pp.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 28, 2016). USFWS. 2019. Pink Mucket Lampsilis abrupta. 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Asheville, North Carolina, Field Office.

USFWS. 1997. Pink Mucket (Lampsilis orbiculata) Species Summary. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. Retreived 12-Jan-2017. URL: https://www.fws.gov/midwest/endangered/clams/pdf/pink-mucket.pdf

USFWS. 2015. Pink Mucket (Lampsilis abrupta) Species Summary. U.S. Fish and Wildlife Service, Arkansas Ecological Field Services Office, Conway, Arkansas. Retrieved 12-Jan-2017. URL: https://www.fws.gov/arkansas-es/Species/Mussels/pinkmucket.html

U.S. Fish and Wildlife Service. 1985. Pink Mucket Pearly Mussel (Lampsilis orbiculata) Recovery Plan. Prepared under contract by Steven Ahlstedt, Tennessee Valley Authority, Norris, Tennessee. 55 pp.

USFWS 1985. Recovery Plan for the Pink Mucket Pearly Mussel Lampsilis orbiculata (Hildreth, 1828). U.S. Fish and Wildlife Service Atlanta, Georgia.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 28, 2016).

USFWS. 2019. Pink Mucket Lampsilis abrupta. 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Asheville, North Carolina, Field Office.

SPECIES ACCOUNT: *Lampsilis altilis* (Finelined pocketbook)

Species Taxonomic and Listing Information

Listing Status: Threatened; March 17, 1993; Southeast Region (R4) (USFWS 2000)

Physical Description

The fine-lined pocketbook is a medium-sized mussel, sub-oval in shape, and rarely exceeds 100 mm (4 in) in length. The ventral margin of the shell is angled posteriorly in females, resulting in a pointed posterior margin. The periostracum is yellow-brown to blackish and has fine rays on the posterior half. The nacre is white, becoming iridescent posteriorly (USFWS 2000).

Taxonomy

Apparently this species has been listed as Lampsilis clarkiana in the literature more often than as Lampsilis altilis. Hanley (1983) was the first to indicate L. altilis may belong to a different genus rather than Lampsilis and that L. altilis is distinct from Lampsilis perovalis, but probably identification of the two taxa have been confused in the literature. Distinct shell morphology in the form L. clarkiana may warrant genetic evaluation in comparison to typical L. altilis (James D. Williams, pers. comm. 10/10/97). Lampsilis altilis, Lampsilis perovalis, Lampsilis subangulata, and Lampsilis australis have been placed into the new genus Hamiota (Roe and Hartfield, 2005) NatureServe 2015).

Historical Range

Alabama River and tributaries, Alabama; tributary rivers and streams of the Tombigbee and Black Warrior Rivers, Mississippi and Alabama; Cahaba River and tributaries, Alabama; Tallapoosa River and tributaries, Alabama, Georgia; and the Coosa River and tributaries, Alabama, Georgia, Tennessee (USFWS 2000).

Current Range

Known populations occur in Upper Cahaba River and the Little Cahaba River, Alabama; Coosa River (Cherokee County, Alabama) and its tributaries, Conasauga River (Murray/Whiffield County, Georgia, Polk County, Tennessee) and Holly Creek(Murray County, Georgia), Terrapin Creek and South Fork Terrapin Creek (Cleburne County, Alabama), Big Canoe Creek (St. Clair County, Alabama), Cheaha Creek (Talladega/Clay County, Alabama), Yellowleaf Creek and its tributary Muddy Prong (Shelby County, Alabama), Kelly Creek and its tributary Shoal Creek (Shelby/St. Clair County, Alabama), Shoal Creek (Clebume County, Alabama), and Tallasahatchee Creek (Talladega County, Alabama); and the Tallapoosa River (Cleburne County, Alabama) and tributaries, Uphapee Creek(Macon County, Alabama), Choctafaula Creek (Macon/Lee County, Alabama), Chewacla Creek(Macon/Lee County, Alabama), Opintlocco Creek (Macon County, Alabama), Cane and Little Cane Creeks (Clebume County, Alabama), Muscadine Creek (Cleburne County, Alabama), Big Creek (Haralson County, GA), McClendon Creek (Paulding County, Georgia) (USFWS 2000).

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the fine-lined pocketbook under the Endangered Species Act of 1973, as amended (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat for the fine-lined pocketbook (Lampsilis altilis) is designated in Units 13, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26; in AL, GA, and TN.

Unit 13. Cahaba River and tributary, Jefferson, Shelby, Bibb Counties, Alabama. Unit 13 encompasses 124 km (77 mi) of river channel in Alabama, including: Cahaba River, 105 km (65 mi) extending from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; Little Cahaba River, 19 km (12 mi), from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama. Scattered individuals of triangular kidneyshell, orange-nacre mucket, and fine-lined pocketbook continue to be collected from the Cahaba drainage (R. Haddock, Cahaba River Society, pers. comm., 2002; McGregor et al., 2000; Shepard et al., 1994). The river is historic habitat for the Alabama moccasinshell, southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 16. Tallapoosa River and tributary, Cleburne County, Alabama and Haralson and Paulding Counties, Georgia. Unit 16 encompasses 161 km (100 mi) of river and stream channel in Alabama and Georgia, including: Tallapoosa River, 137 km (85 mi) extending from U.S. Highway 431, Cleburne County, Alabama, upstream to the confluence of McClendon and Mud Creeks, Paulding County, Georgia; and Cane Creek, 24 km (15 mi), from confluence with Tallapoosa River, upstream to Section 33/4 Line (T15S, R11E), Cleburne County, Alabama. This extensive area of main channel and tributary habitat supports scattered, small numbers of the fine-lined pocketbook (Devris, 1997; Irwin et al., 1998; Irwin pers. comm., 2000). There have been site collections of fine-lined pocketbook in the extreme lowest reaches of several small tributaries to the Tallapoosa Unit, including Little Cane Creek, Big Creek, McClendon Creek, and Muscadine Creek, and there are likely to be others. We believe these small populations are dependent upon the main stem Tallapoosa River for recruitment.

Unit 17. Uphapee/Choctafaula/ Chewacla Creeks, Macon, Lee Counties, Alabama. Unit 17 encompasses 74 km (46 mi) of stream channel in Alabama, including: Uphapee Creek, 18 km (11 mi) of river channel extending from Alabama Highway 199, upstream to confluence of Opintlocco and Chewacla Creeks, Macon County, Alabama; Choctafaula Creek, 11 km (7 mi), from confluence with Uphapee Creek, upstream to Macon County Road 54, Macon County, Alabama; Chewacla Creek, 29 km (18 mi), from confluence with Opintlocco Creek, Macon County, Alabama, upstream to Lee County Road 159, Lee County, Alabama; Opintlocco Creek, 16 km (10 mi), from confluence with Chewacla Creek, upstream to Macon County Road 79, Macon County, Alabama. This stream network supports small and localized populations of the fine-lined pocketbook, ovate clubshell, and southern clubshell (M. Gangloff, Auburn University, in litt., 2001; Gangloff, 2002; McGregor, 1993; Pierson, 1991a).

Unit 18. Coosa River (Old River Channel) and tributary, Cherokee, Calhoun, Cleburne Counties, Alabama. Unit 18 encompasses 78 km (48 mi) of river channel in Alabama, including: Coosa River, 18 km (11 mi) extending from the powerline crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Coosa River, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi) from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama. The short reach of the Coosa River continues to support a fairly robust population of the southern clubshell, and a few individuals of the fine-lined pocketbook (Herod et al., 2001). The fine-lined pocketbook and southern clubshell have also been recently collected from Terrapin Creek (Feminella and Gangloff, 2000). This area is within the range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 19. Hatchet Creek, Coosa, Clay Counties, Alabama. Unit 19 encompasses 66 km (41 mi) of the Hatchet Creek channel in Alabama, extending from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama. The fine-lined pocketbook occurs within this reach (Feminella and Gangloff, 2000; Pierson, 1992b). Hatchet Creek is within the historic range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, southern clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 20. Shoal Creek, Calhoun, Cleburne Counties, Alabama. Unit 20 encompasses 26 km (16 mi) of stream channel in Alabama, extending from the headwater of Whitesides Mill Lake, Calhoun County, Alabama, upstream to the tailwater of Coleman Lake Dam, Cleburne County, Alabama. The fine-lined pocketbook, southern pigtoe, and triangular kidneyshell survive in Shoal Creek (Haag et al., 1999; Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson, 1992b). Shoal Creek is within historic range of the Coosa moccasinshell.

Unit 21. Kelly Creek and tributary, Shelby, St. Clair Counties, Alabama. Unit 21 encompasses 34 km (21 mi) of stream channel in Alabama, including: Kelly Creek, 26 km (16 mi) extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama; Shoal Creek, 8 km (5 mi), from confluence with Kelly Creek, St. Clair County, Alabama, upstream to St. Clair/ Shelby County Line, St. Clair County, Alabama. Kelly/Shoal Creeks continue to support scattered individuals of the fine-lined pocketbook, and the southern clubshell and triangular kidneyshell survive in Kelly Creek (Pierson pers. comm., 1995; Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream complex is historic habitat for the southern pigtoe, Coosa moccasinshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 22. Cheaha Creek, Talladega, Clay Counties, Alabama. Unit 22 encompasses 27 km (17 mi) of the Cheaha Creek channel, extending from its confluence with Choccolocco Creek, Talladega County, Alabama, upstream to the tailwater of Chinnabee Lake, Clay County, Alabama. The finelined pocketbook and southern pigtoe survive within this reach (Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson, 1992b, 1993). Cheaha Creek is in the historic range of the Coosa moccasinshell and triangular kidneyshell.

Unit 23. Yellowleaf Creek and tributary, Shelby County, Alabama. Unit 23 encompasses 39 km (24 mi) of stream channel, including: Yellowleaf Creek, 32 km (20 mi), extending from Alabama Highway 25, upstream to Shelby County Road 49; Muddy Prong, 7 km (4 mi), extending from confluence with Yellowleaf Creek, upstream to U.S. Highway 280, Shelby County, Alabama. Yellowleaf and Muddy Prong Creeks are currently inhabited by the fine-lined pocketbook (Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson in litt., 2000). Yellowleaf Creek is in the historic range of the Coosa moccasinshell, southern pigtoe, and triangular kidneyshell.

Unit 24. Big Canoe Creek, St. Clair County, Alabama. Unit 24 encompasses 29 km (18 mi) of the Big Canoe Creek channel, extending from its confluence with Little Canoe Creek at the St. Clair/ Etowah County line, St. Clair County, upstream to the confluence of Fall Branch, St. Clair County, Alabama. The southern clubshell, southern pigtoe, and triangular kidneyshell are surviving in low numbers in Big Canoe Creek (Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream is also historic habitat for the fine-lined pocketbook, ovate clubshell, Coosa moccasinshell, upland combshell, and southern acornshell.

Unit 25. Oostanaula River/Coosawattee River/Conasauga River/Holly Creek, Floyd, Gordon, Whitfield, Murray Counties, Georgia; Bradley, Polk Counties, Tennessee. Unit 25 encompasses 206 km (128 mi) of river and stream channel in Georgia and Tennessee, including: Oostanaula River, 77 km (48 mi) extending from its confluence with the Etowah River, Floyd County, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; Coosawattee River, 15 km (9 mi), from confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; Conasauga River, 98 km (61 mi), from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to the Murray County Road 2, Murray County, Georgia; Holly Creek, 16 km (10 mi), from confluence with Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia. This extensive riverine reach continues to support small and localized populations of fine-lined pocketbook, southern pigtoe, triangular kidneyshell, Alabama moccasinshell, and Coosa moccasinshell. The triangular kidneyshell survives throughout this unit, while the fine-lined pocketbook, southern pigtoe, and Coosa moccasinshell appear to be currently restricted to the Conasauga River and Holly Creek and the southern clubshell appears restricted to a small 15 km (9 mi) reach of the Conasauga River (Evans, 2001; Johnson and Evans, 2000; Pierson in litt., 1993; Williams and Hughes, 1998). The Alabama moccasinshell is currently known to survive only in the Holly Creek portion of this Unit (Evans, 2001; Johnson and Evans, 2000). The Oostanaula/ Coosawattee/Conasauga Unit also contains historic habitat for the southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 26. Lower Coosa River, Elmore County, Alabama. Unit 26 encompasses 13 km (8 mi) of the Lower Coosa River channel, extending from Alabama State Highway 111 bridge, upstream to Jordan Dam, Elmore County, Alabama. This river reach is within the historic range of fine-lined pocketbook, southern clubshell, Alabama moccasinshell, Coosa moccasinshell, ovate clubshell, southern pigtoe, triangular kidneyshell, upland combshell, and southern acornshell. (Johnson, 2002; Pierson, 1991a).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the fine-lined pocketbook (Lampsilis altilis) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: All mussels are filter feeders. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS 2000).

Reproduction Narrative

Adult: Glochidia measure only a fraction of a mm in size, and a single female may produce hundreds of thousands. All glochidia, with the possible exception of two species, appear to be obligate parasites of aquatic vertebrates. Gravid females have been collected March through June. They have been observed releasing glochidia in a single, large mass termed a superconglutinate. Redeye bass, spotted bass, largemouth bass, and green sunfish have been identified as suitable hosts. While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years (USFWS 2000).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, deep water (> 10 m), dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2000)

Environmental Specificity

Adult: Moderate (NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Historically found in large river to small creek habitats. Recent collections have been from stable sand/gravel/cobble substrate in moderate to swift currents in small streams above the Fall Line (USFWS 2000). The environmental specificity of this species is moderate. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater mussels into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

Declining (NatureServe 2015)

Number of Populations:

6 - 80 (NatureServe 2015)

Population Size:

Unknown (NatureServe 2015)

Population Narrative:

This species is a declining regional endemic that was once widespread throughout the Mobile River basin in the Tombigbee, Black Warrior, Cahaba, Alabama, Tallapoosa, and Coosa Rivers in Alabama, Georgia, Mississippi, and Tennessee but has been reduced to a few dozen widespread but isolated occurrences across its range. The range extent is 100 - 400 square miles, with an unknown population size. There are 6 - 80 occurrences of this species, with 4 - 12 occurrences having good viability/integrity (NatureServe 2015).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species. The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin. Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a mollusk-eating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: The low numbers of individuals of this species at most sites suggest marginal habitat conditions. All drainage populations remain susceptible to stochastic and chronic events (e.g., spills, drought and/or landuse runoff) (USFWS, 2008).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel

larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Stressor: Mining (USFWS 2000)
Exposure:
Response:
Consequence:
Narrative: Mining for coal, sand, gravel, or gold is locally concentrated in areas within the Basin. Active and inactive coal mines are founa in the upland drainages ofthe Black Warrior River, and in portions ofthe Cahaba and Coosa river drainages. Runofffrom coal surface mining has resulted in acidification, mineralization, and sedimentation ofstreams and rivers, all ofwhich are detrimental to aquatic species (Mason 1991). Such impacts are more closely associated with past activities and abandoned mines,since presently operating mines are required to employ environmental safeguards established by the Federal Surface Mining Control and Reclamation Act of 1977 and the Clean WaterAct of 1972 (USFWS 2000).

Stressor: Pollution (USFWS 2000)
Exposure:
Response:
Consequence:
Narrative: Pollution from inadequately treated effluent (waste discharge) ofindustrial plants and/or sewage treatment plants can eliminate, or reduce the density and diversity, of riverine species (Hynes 1970). Effluents may be toxic to some species or may result in decreased dissolved oxygen concentrations, increased acidity and conductivity, and other changes in water chemistry which may adversely affect aquatic species. Carpet mills and fabric dying mills are believed to have had a major impact on stream communities in Coosa River tributaries in Alabama and Georgia (Hurd 1974). Large industrial plants, such as paper mills and refineries, are generally located on largermain-stem rivers because oftheir greater assimilation capacity (the capacity of a body ofwater to assimilate pollutants without environmental harm). When that assimilation capacity is exceeded, large river biotic communities are adversely impacted. In the past two decades, effluents from such industries have had less impact on the aquatic ecosystem because of the implementation of pollution control standards established by State and Federal water quality laws. In some stream/river segments, however, such improvements may have been negated by increases in the number ofdischarges.Excessive nutrient input from multiple sources (e.g, nitrogen and phosphorus from fertilizer, sewage waste, animal manure, etc.) into an aquatic system can also have cumulative effects. In fact, land surface runoffcontributes the majority

ofhuman-induced nutrients to water bodies throughout the country (Louisiana Department ofEnvironmental Quality 1995). Large amounts of nutrients in surface runoffcan result in periodic low dissolved oxygen levels that are detrimental to aquatic species (eutrophication) (Hynes 1970). They also promote excessive algal growth that can eliminate habitat for aquatic species requiring clean rock or gravel substrate during one or more oftheirlife stages (e.g., Hartfield and Hartfield 1996). Excessive nutrients within a stream or river can also indicate the potential presence ofpathogenic microorganisms (USFWS 2000).

Recovery

Reclassification Criteria:
Reclassification does not appear to be a realistic goal for this species at this time (USFWS 2000).

Delisting Criteria:
1) At least ten (I 0) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (Factors A) (USFWS, 2019).

2) At least two (2) populations (as defined in Criteria 1) occupies each of the presently occupied sub-basins (Coosa, Cahaba, and Tallapoosa), and populations (as defined in Criteria 1) occupy both mainstem and tributary systems (Factors A and E) (USFWS, 2019).

3) Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A-E) (USFWS, 2019).

Recovery Actions:
- Protect habitat integrity and quality (USFWS 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS 2000).
- The U.S. Forest Service has funded mussel surveys in streams under its jurisdiction, and has revised and implemented protective stream management zone guidelines on National Forest lands in Alabama. Surveys of potential habitat are being conducted by State, Federal, and private biologists (USFWS 2000).
- Develop measurable recovery criteria for this species (USFWS 2008).

- Develop and implement plan to quantify and monitor surviving populations (USFWS 2008).
- Develop and implement plan to describe and monitor habitat conditions where the mussels survive (USFWS 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan.
- Work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS 2000).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp

USFWS 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126. July 1, 2004. Pages 40084 - 40171

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 28, 2016).

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2019. Finelined Pocketbook Amendment 1 to the U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Lampsilis bergmanni* (Guadalupe Fatmucket)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

At this time the morphological variation (shell and soft tissue anatomy) remains undescribed. Aside from genetic confirmation the current distinguishing feature between Guadalupe fatmucket and Texas fatmucket is the location in which the specimen is found; being either the Guadalupe River basin or the Colorado River basin, respectively. The Guadalupe fatmucket (Lampsilis bergmanni) was recently proposed as a separate and distinct species from Texas fatmucket (Lampsilis bracteata; Inoue et al. 2019, entire). At this time little is known about the inter-species genetic variation across the populations in the Upper Guadalupe River basin. Genetic information suggests any Lampsilis spp. downstream of Canyon Lake Reservoir and the confluence of the San Marcos River are Louisiana fatmucket (Lampsilis hydiana) (USFWS, 2022).

Taxonomy

The Guadalupe fatmucket (Lampsilis bergmanni) was recently described as a separate and distinct species from Texas fatmucket (Lampsilis bracteata; Inoue et al. 2019, entire). The Service now recognizes Lampsilis bracteata to only occur in the Colorado River basin while Lampsilis bergmanni is now recognized to only occur in the Guadalupe river basin. The two species are assumed to have similar habitat and host fish needs. The following taxonomic treatment follows Williams et al. (2017, pp. 35, 39). CLASS Bivalvia Linnaeus, 1758 ORDER Unionida Gray, 1854 FAMILY Unionidae Rafinesque, 1820 SUBFAMILY Ambleminae Rafinesque, 1820 TRIBE Lampsilini Ihering, 1901 GENUS Lampsilis Rafinesque, 1820 SPECIES Lampsilis bracteata Gould, 1855 Lampsilis bergmanni Inoue et al. 2019 (USFWS, 2022)

Historical Range

The Guadalupe fatmucket (Lampsilis bergmanni) was previously assigned to the same species as the Texas fatmucket (Lampsilis bracteata). However, following genetic analyses (Inoue et. al. 2019, entire), it is now recognized as a separate and distinct species occurring within the Guadalupe River. For this reason, what we now consider Guadalupe fatmucket populations are referred to as the Texas fatmucket in the literature documenting its occurrences prior to 2018. In the Guadalupe River basin, the Guadalupe fatmucket occupied approximately 240 km (150 mi) of the Guadalupe River, from Gonzalez County upstream to Kerr County, including the North Guadalupe River, Johnson Creek, and the Blanco River. Strecker (1931, pp. 66-8) reported what would now be considered a Guadalupe fatmucket from a lake in Victoria County in the lower Guadalupe River drainage, but this is probably a misidentified Louisiana fatmucket (L. hydiana), which is known to occur in lakes and impoundments (USFWS, 2022).

Current Range

The Service now recognizes Lampsilis bracteata to only occur in the Colorado River basin while Lampsilis bergmanni is now recognized to only occur in the Guadalupe river basin. The two species are assumed to have similar habitat and host fish needs (USFWS, 2022).

Critical Habitat Designated

Yes; 7/5/2024.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli), and threatened species status for the Texas fawnsfoot (Truncilla macrodon), seven species of freshwater mussels from central Texas. We also issue a rule under section 4(d) of the Act for the Texas fawnsfoot that provides measures that are necessary and advisable to provide for the conservation of the Texas fawnsfoot. In addition, we designate critical habitat for all seven species. In total, approximately 1,577.5 river miles (2,538.7 river kilometers) in Blanco, Brown, Caldwell, Coleman, Comal, Concho, DeWitt, Gillespie, Gonzales, Guadalupe, Hays, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, Palo Pinto, Parker, Runnels, San Saba, Shackelford, Stephens, Sutton, Throckmorton, Tom Green, Travis, and Victoria Counties, Texas, fall within the boundaries of the critical habitat designation. This rule applies the protections of the Act to these species and their designated critical habitat (89 FR 48034).

Critical Habitat Designation

We have determined that the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli) meet the Act's definition of endangered species, and the Texas fawnsfoot (Truncilla macrodon) meets the Act's definition of a threatened species; therefore, we are listing them as such, finalizing a rule under section 4(d) of the Act for the Texas fawnsfoot, and designating critical habitat. Both listing a species as an endangered or threatened species and designating critical habitat can be completed only by issuing a rule through the Administrative Procedure Act rulemaking process (5 U.S.C. 551 et seq.). What this document does. This rule makes final the listing of the Guadalupe fatmucket, Texas fatmucket, Guadalupe orb, Texas pimpleback, Balcones spike, and false spike as endangered species, and the Texas fawnsfoot as a threatened species with a rule issued under section 4(d) of the Act (a ''4(d) rule''). In addition, this rule designates critical habitat for all seven central Texas mussel species in 20 units (including 32 subunits) totaling 1,577.5 river miles (2,538.7 river kilometers (km)) on private, State, and Federal property within portions of 31 counties in Texas (89 FR 48034).

Primary Constituent Elements/Physical or Biological Features

Within this area, the physical or biological features essential to the conservation of Guadalupe fatmucket consist of the following components within waters and streambeds up to the ordinary high-water mark: (i) Flowing water at moderate to high rates with sufficient depth to remain sufficiently cool and oxygenated during low-flow periods; (ii) Substrate including bedrock and boulder crevices, point bars, and vegetated run habitat comprising sand, gravel, and larger cobbles; (iii) Green sunfish (Lepomis cyanellus), bluegill (L. macrochirus), largemouth bass (Micropterus salmoides), and Guadalupe bass (M. treculii) present; and (iv) Water quality parameters within the following ranges: (A) Dissolved oxygen greater than 2 milligrams per liter (mg/L); (B) Salinity less than 2 parts per thousand; (C) Total ammonia less than 0.77 mg/ L total ammonia nitrogen; (D) Water temperature below 29 °C (84.2 °F); and (E) Low levels of contaminants (89 FR 48034).

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the central Texas mussels may require special management considerations or protections to reduce the following threats: increased fine sediment, changes in water quality, altered hydrology from both inundation and flow loss/scour, predation and collection, and barriers to fish movement. Management activities that could ameliorate these threats include, but are not limited to: Use of best management practices (BMPs) designed to reduce sedimentation, erosion, and bank side destruction; protection of riparian corridors and retention of sufficient canopy cover along banks; exclusion of livestock and nuisance wildlife (feral hogs, exotic ungulates); moderation of surface and groundwater withdrawals to maintain natural flow regimes; increased use of stormwater management and reduction of stormwater flows into the systems; use of highest water quality standards for wastewater and other return flows; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the occupied areas we are designating as critical habitat contain the PBFs that are essential to the conservation of the species and that may require special management considerations or protection. Special management considerations or protection may be required of the Federal action agency to eliminate, or to reduce to negligible levels, the threats affecting the PBFs of each unit (89 FR 48034).

Life History

Food/Nutrient Resources

Food Source

Larvae: Glochidia derive what little nutrition they need from their obligate fish hosts (USFWS, 2022).

Juvenile: juvenile mussels can use their feet to collect food items from sediments (pedal feeding (USFWS, 2022).

Adult: Adult freshwater mussels, including Central Texas mussels, are filter-feeders, siphoning suspended phytoplankton, zooplankton, rotifers, protozoans, detritus and dissolved organic matter from the water column (Strayer et al. 2004, p. 430) and from sediment (USFWS, 2022).

Reproductive Strategy

Adult: Long term brooder

Dependency on Other Individuals or Species

Adult: Host fishes are known to be members of the Family Centrarchidae (sunfishes), including bluegill (Lepomis macrochirus), green sunfish (Lepomis cyanellus), Guadalupe bass (Micropterus treculii), and largemouth bass (Micropterus salmoides) (Howells 1997, p. 257; Johnson et al. 2012, p. 148; Howells 2014, p. 41; Ford and Oliver 2015, p. 4; Bonner et al. 2018, p. 9). Members of the Lampsilini tribe can expel conglutinates and are known to use mantle lures (Barnhart et al. 2008, p. 377) to attract sight feeding fishes that attack and rupture the marsupium, becoming infested by glochidia (p. 380). These species are long-term brooders (bradytictic) (USFWS, 2022).

Key Resources Needed for Breeding

Adult: Guadalupe fatmucket collected from the Upper Guadalupe River (near Comfort, Texas) averaged 50.69 mm

Reproduction Narrative

Adult: Members of the Lampsilini tribe can expel conglutinates and are known to use mantle lures (Barnhart et al. 2008, p. 377) to attract sight feeding fishes that attack and rupture the marsupium, becoming infested by glochidia (p. 380). These species are long-term brooders (bradytictic) (USFWS, 2022).

Habitat Type

Adult: Riverine

Habitat Narrative

Adult: The Guadalupe fatmucket habitat requirements are assumed to be similar to that of the Texas fatmucket. The Texas fatmucket occurs in flowing streams and rivers of the Edwards Plateau with substrates of “firm mud, stable sand, and gravel bottoms, in shallower waters” sometimes in bedrock fissures or among roots of bald cypress (Taxodium distichum) and other aquatic vegetation (Howells 2014, p. 41) (Table 2.4). The Texas fatmucket has been described as more vulnerable to extreme low flows and positively associated with spring outflows of the Edwards Plateau (Bonner et al. 2018, p. 9). In a laboratory dewatering experiment, the median Lethal Time (LT50) was 2.86 days and Texas fatmucket did not exhibit a behavioral movement response to the dewatering (Bonner et al. 2018, pp. 8-9, 196). Recent thermal tolerance studies on Texas fatmucket found a lethal temperature for 50% of the population (LT50) during a 24-hour period of 34.7°C (USFWS, 2022).

Dispersal/Migration

Motility/Mobility

Adult: Limited

Dispersal

Adult: low

Dispersal/Migration Narrative

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Resiliency:

The Guadalupe fatmucket is known to currently occur in the Guadalupe River basin. The Guadalupe basin contains the only known population of Guadalupe fatmucket. This population is currently unhealthy due to a combination of low abundance and low evidence of recruitment, which are likely correlated and possibly related to Allee effects of small populations (USFWS, 2022).

Representation:

We consider the Guadalupe fatmucket to have representation from a single population in the upper reaches of the Guadalupe River and connected tributaries near Kerrville, Texas (USFWS, 2022).

Redundancy:

The Guadalupe River basin has one current population and therefore exhibits no redundancy (USFWS, 2022).

Number of Populations:

One

Population Narrative:

The Guadalupe fatmucket (Lampsilis bergmanni) was previously assigned to the same species as the Texas fatmucket (Lampsilis bracteata). However, following genetic analyses (Inoue et. al. 2019, entire), it is now recognized as a separate and distinct species occurring within the Guadalupe River. For this reason, what we now consider Guadalupe fatmucket populations are referred to as the Texas fatmucket in the literature documenting its occurrences prior to 2018. In the Guadalupe River basin, the Guadalupe fatmucket occupied approximately 240 km (150 mi) of the Guadalupe River, from Gonzalez County upstream to Kerr County, including the North Guadalupe River, Johnson Creek, and the Blanco River. Strecker (1931, pp. 66-8) reported what would now be considered a Guadalupe fatmucket from a lake in Victoria County in the lower Guadalupe River drainage, but this is probably a misidentified Louisiana fatmucket (L. hydiana), which is known to occur in lakes and impoundments. The Texas fatmucket was previously believed to occur in both the Colorado and Guadalupe River basins of the east-central portions of the Edwards Plateau ecoregion, known as the “Hill Country” of Central Texas (Figure 3.3). However, following genetic analyses by Inoue et al. (2019, entire), populations of the Texas fatmucket from the Colorado River basin are now considered a separate and distinct species from the populations in the Guadalupe River basin, which are now known as the Guadalupe fatmucket (Lampsilis bergmanni). The Texas fatmucket once existed with historical populations in at least 14 rivers in the upper Colorado River basin of the east-central portions of the Edwards Plateau ecoregion, known as the “Hill Country” of Central Texas (Figure 3.3). In the Colorado River, it ranged from Travis County upstream approximately 320 kilometers (km) ((200 miles (mi)) to Runnels County. It was also found in many tributaries including the Pedernales, Llano, San Saba, and Concho Rivers, and Jim Ned, Elm, and Onion Creeks (Howells et al. 1996, p. 61). Howells (2004, p. 7) noted that no live unionids (native freshwater mussels) were reported from Elm Creek or from the Colorado River near Ballinger, Texas, in August 2003. Strecker (1931, p. 39) described Texas fatmucket as being “especially common in the San Saba and Llano rivers” and attaining high densities in the Concho River and notes locations on Cypress Creek (Blanco County), San Saba River in Menard and McCulloch Counties, Llano River in Mason County, Colorado River in Runnels County, and South Concho River in Tom Green County. A Salado Creek record from Bell County (Strecker 1931, pp. 62-3) is also probably a misidentified Louisiana fatmucket because Texas fatmucket is not known to occur in the Brazos River basin or its tributaries (Howells et al. 1996, p. 61; Howells 2010c, p. 6). In the San Antonio River basin, questionable records exist from the Medina River in Bexar County upstream to the City of San Antonio, as well as in the Medina River and Cibolo Creek (Howells et al. 1996, p. 61; Howells 2010c, p. 6). San Antonio River accounts of Texas fatmucket are most likely misidentified Louisiana fatmucket (Lampsilis hydiana). Given extensive mussel survey efforts in the San Antonio River basin over the last 30 years (San Antonio River Authority 2017, p. 1), it is likely that additional records would exist if Texas fatmucket were present in the San Antonio River or its tributaries (Randklev 2018, entire). Therefore, this report does not consider the Texas fatmucket or the Guadalupe fatmucket to have historically occurred in the San Antonio River basin (USFWS, 2022).

Threats and Stressors

Stressor: Increased fine sediment (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Juvenile and adult Central Texas mussels inhabit microsites that have abundant interstitial spaces, or small openings in an otherwise closed matrix of substrate, created by gravel, cobble, boulders, bedrock crevices, tree roots, and other vegetation, with some amount of fine sediment (i.e., clay and silt) necessary to provide appropriate shelter. However, excessive amounts of fine sediments can reduce the number of appropriate microsites in an otherwise suitable mussel bed by filling in these interstitial spaces and can smother mussels in place. Central Texas mussels generally require stable substrates, and loose silt deposits do not generally provide for substrate stability. Interstitial spaces provide essential habitat for juvenile mussels. Juvenile freshwater mussels burrow into interstitial substrates, making them particularly susceptible to degradation of this habitat feature. When clogged with sand or silt, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability. While adult mussels can be physically buried by excessive sediment, “the main impacts of excess sedimentation on unionids are often sublethal” and include interference with feeding mediated by valve closure (Brim Box and Mossa 1999, p. 101). Many land use activities can result in excessive erosion, sediment production and channel instability; including, but not limited to, logging, crop farming, ranching, mining, and urbanization (USFWS, 2022).

Stressor: Changes in water quality
Exposure:
Response:
Consequence:
Narrative: Above all else, freshwater mussels require water in sufficient quantity and quality on a consistent basis to complete their life cycles and those of their host fish. Urban growth and other anthropogenic activities across Texas are placing increased demands on limited water supplies that in turn, can have deleterious effects on water quality. Water quality can be degraded through contamination or alteration of water chemistry. Chemical contaminants are ubiquitous throughout the environment and are a major reason for the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Chemicals enter the environment through both point and nonpoint source discharges, including hazardous spills, industrial wastewater, municipal effluents, and agricultural runoff. These sources contribute organic compounds, trace metals, pesticides, and a wide variety of newly emerging contaminants (e.g., pharmaceuticals) that comprise some 85,000 chemicals in commerce today that are

released to the aquatic environment (EPA 2018, p. 1). The extent to which environmental contaminants adversely affect aquatic biota can vary depending on many variables such as concentration, volume, and timing of the release, but species diversity and abundance consistently ranks lower in waters that are known to be polluted or otherwise impaired by contaminants. Freshwater mussels are not generally found for many miles downstream of municipal wastewater treatment plants (Gillis et al. 2017, p. 460; Goudreau et al. 1993, p. 211; Horne and McIntosh, p. 119). For example, transplanted common freshwater mussels (Amblema plicata and Corbicula fluminea) showed reduced growth and survival below a wastewater treatment plant (WWTP) outfall relative to sites located upstream of the WWTP in Wilbager Creek (a tributary to the Colorado River in Travis County, Texas). Water chemistry was altered by the wastewater flows at downstream sites, with elevated constituents in the water column that included copper, potassium, magnesium, and zinc (Nobles and Zhang 2015, p.11; Duncan and Nobles 2012, p. 8). Contaminants released during hazardous spills are also of concern. Although spills are relatively short-term events and may be localized, depending on the types of substances and volume released, water resources nearby can be severely impacted and degraded for years after the incident (USFWS, 2022).

Stressor: Altered Hydrology – Inundation
Exposure:
Response:
Consequence:
Narrative: Central Texas mussels are adapted to flowing water (lotic habitats) rather than standing water (lentic habitats) and require free-flowing water to survive. Low flow events (including stream drying) and inundation can eliminate appropriate habitat for Central Texas mussels, and while these species can survive these events for a very short duration, populations that experience prolonged drying events or repeated drying events will not persist. Inundation has primarily occurred upstream of dams, both large (such as the Highland Lakes and other major flood control and water supply reservoirs) and small (low water crossings and diversion dams typical of the tributaries and occurring usually on privately owned lands). Inundation causes an increase in sediment deposition, eliminating the crevices that many Central Texas mussel species inhabit. Inundation also includes the effects of reservoir releases where frequent variation in surface water elevation acts to make habitats unsuitable for Central Texas mussels. In large reservoirs, deep water is very cold and often devoid of oxygen and necessary nutrients. Cold water (less than 11 °Celsius (C) or 52 °Fahrenheit (F)) has been shown to stunt mussel growth and delay or hinder spawning. The Central Texas mussels are not known to tolerate inundation under large reservoirs. Further, deep water reservoirs with bottom release (like Canyon Reservoir, which supports a recreational rainbow and brown trout fishery) can affect water temperatures several miles downriver. The water temperature remains below 21.1°C for the first 6.3-km (3.9 miles) of the 22.2-km (13.8 miles) Canyon Reservoir tailrace (USFWS, 2022).

Stressor: Altered Hydrology – Flow Loss and Scour
Exposure:
Response:
Consequence:
Narrative: Very low water levels are detrimental to Central Texas mussel populations as well. Droughts that have occurred in the recent past have led to extremely low flows in several Central Texas rivers. Many of these rivers have some resiliency to drought because they are spring fed (Colorado tributaries, Guadalupe), are very large (lower Brazos and Colorado), or have significant

return flows (Trinity) but drought in combination with increased groundwater pumping may lead to lower river flows of longer duration than have been recorded in the past. Reservoir releases can be managed to some extent during drought conditions to prevent complete dewatering below many major reservoirs (USFWS, 2022).

Stressor: Predation, Collection, Disease, and Invasive Species
Exposure:
Response:
Consequence:
Narrative: Predation on freshwater mussels is a natural ecological interaction. Raccoons, snapping turtles, and fish are known to prey upon Central Texas mussels. Under natural conditions, the level of predation occurring within Central Texas mussel populations is not likely to pose a significant risk to any given population. However, during periods of low flow, terrestrial predators have increased access to portions of the river that are otherwise too deep under normal flow conditions. High levels of predation during drought have been observed on the Llano and San Saba rivers. As drought and low flow are predicted to occur more often and for longer periods due to the effects of future climate change, the Hill Country tributaries (of the Colorado River) in particular are expected to experience additional predation pressure into the future, and this may become especially problematic in the Llano and San Saba Rivers. Predation is expected to be less of a problem for the lower portions of the main stem river populations, as the rivers are significantly larger than the tributary streams and Central Texas mussels are thus less likely to be found in exposed or very shallow habitats (USFWS, 2022).

Stressor: Barriers to fish movement
Exposure:
Response:
Consequence:
Narrative: entral Texas mussels historically colonized new areas through movement of infested host fish, as newly metamorphosed juveniles would excyst from host fish in new locations. Today, the remaining Central Texas mussel populations are significantly isolated from one another by major reservoirs such that recolonization of areas previously extirpated is extremely unlikely if not impossible due to existing contemporary barriers to host fish movement. There is currently no opportunity for interaction among any of the extant Central Texas mussel populations as they are all fragmented from one another by reservoirs. The overall distribution of mussels is, in part, a function of the dispersal of their host fish. There is limited potential for immigration between populations other than through the attached glochidia being transported to a new area or to another population. Small populations are more affected by this limited immigration potential because they are susceptible to genetic drift, resulting from random loss of genetic diversity, and inbreeding depression. At the species level, populations that are eliminated due to stochastic events cannot be recolonized naturally, leading to reduced overall redundancy and representation (USFWS, 2022).

Stressor: Climate change
Exposure:
Response:
Consequence:
Narrative: Climate change has been documented as has already taken place, and continued greenhouse gas emissions at or above current rates will cause further warming

(Intergovernmental Panel on Climate Change (IPCC) 2013, pp. 11-12). Warming in Texas is expected to be greatest in the summer (Maloney et al. 2014, p. 2236, Fig. 3). In Texas, the number of extremely hot days (high temperatures exceeding 95º Fahrenheit) is expected to double by around 2050 (Kinniburgh et al. 2015, p. 83). West Texas is an area expected to show greater responsiveness to the effects of climate change (Diffenbaugh et al. 2008, p. 3). Changes in stream temperatures are expected to reflect changes in air temperature, at a rate of approximately 0.6 – 0.8°C increase in stream water temperature for every 1°C increase in air temperature (Morrill et al. 2005, pp. 1-2, 15) and with implications for temperature-dependent water quality parameters such as DO and ammonia toxicity. Given that the Central Texas mussels exist at or near the ecophysiogical edge of climate and habitat gradients of unionid biogeography in North America, it is likely that they may be particularly vulnerable to future climate changes in combination with current and future stressors (USFWS, 2022).

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

USFWS. 2022. Species Status Assessment Report for the Central Texas Mussels: False spike (Fusconaia mitchelli) Balcones spike (Fusconaia iheringi) Texas fatmucket (Lampsilis bracteata) Texas fawnsfoot (Truncilla macrodon) Texas pimpleback (Cyclonaias petrina) Guadalupe fatmucket (Lampsilis bergmanni) Guadalupe orb (Cyclonaias necki). Version 2.1. USFWS. Region 2. Albuquerque, NM.

89 FR. No. 108. Pages 48034-48130. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, Balcones Spike, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. Final Rule.

SPECIES ACCOUNT: *Lampsilis bracteata* (Texas fatmucket)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Texas fatmucket is a large, elongated mussel that reaches a maximum length of 100 millimeters (mm) (3.94 inches (in)) (Howells 2010c, p. 2). The shell is oval to elliptical or somewhat rhomboidal and tan to greenish-yellow with numerous irregular, wavy, and broad and narrow dark brown rays, with broad rays widening noticeably as they approach the ventral (underside) margin. The nacre (inside of the shell) is white with occasional yellow or salmon coloration and iridescent posteriorly (Howells 2010c, p. 2). Females have mantle flaps (extensions of the tissue that covers the visceral mass) that often resemble minnows, including eye spots, lateral line, and fins (Howells 2010c, p. 2).

Taxonomy

The Texas fatmucket (Lampsilis bracteata) was first described in 1855 by Gould as Unio bracteatus and later moved to the genus Lampsilis by Simpson (1900, p. 543). Some forms found in headwater streams were historically split into a different species, L. elongatus, but they have since been determined to be L. bracteata that were ecophenotypes (individuals whose shape is determined by their environment) (Howells 2010c, p. 5). The Texas fatmucket is recognized by the Committee on Scientific and Vernacular Names of Mollusks of the Council of Systematic Malacologists, American Malacological Union (Turgeon et al. 1998, p. 34), and we recognize it as a valid species.

Historical Range

The Texas fatmucket historically had populations in at least 18 rivers in the upper Colorado, Guadalupe, and San Antonio River systems in the Texas Hill Country and east-central Edwards Plateau region of central Texas. In the Colorado River, it ranged from Travis County upstream approximately 320 kilometers (km) (200 miles (mi)) to Runnels County. It was also found in many tributaries of the Colorado River, including the Pedernales, Llano, San Saba, and Concho Rivers, and Jim Ned, Elm, and Onion Creeks (Howells et al. 1996, p. 61). In the Guadalupe-San Antonio River basin, the Texas fatmucket occupied approximately 240 km (150 mi) of the Guadalupe River, from Gonzales County upstream to Kerr County, including the North Guadalupe River, Johnson Creek, and the Blanco River. In the San Antonio River, it ranged from its confluence with the Medina River in Bexar County upstream to the City of San Antonio, as well as in the Medina River and Cibolo Creek (Howells et al. 1996, p. 61; Howells 2010c, p. 6). Strecker (1931, pp. 6668) reported Texas fatmucket from a lake in Victoria County in the lower Guadalupe River drainage (Howells 2010c, p. 6), but this is probably a misidentified Louisiana fatmucket, which occurs in lakes or impoundments. A Salado Creek record from Bell County (Strecker 1931, pp. 6263) is also probably a misidentified Louisiana fatmucket, since the Texas fatmucket is not known to occur in the Brazos River basin or its western tributaries (Howells et al. 1996, p. 61; Howells 2010c, p. 6).

Current Range

The Texas fatmucket has declined significantly range wide and is now known from only nine streams in the Colorado and Guadalupe River systems in very limited numbers. Most existing populations are represented by only one or two individuals and are likely not stable or recruiting (juvenile mussels joining the adult population). In the streams where the species is extant (surviving), populations are highly fragmented and restricted to short reaches with few exceptions. The Texas fatmucket has been considered a species of special concern by some malacologists for several decades (Athearn 1970, p. 28).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 7/5/2024.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli), and threatened species status for the Texas fawnsfoot (Truncilla macrodon), seven species of freshwater mussels from central Texas. We also issue a rule under section 4(d) of the Act for the Texas fawnsfoot that provides measures that are necessary and advisable to provide for the conservation of the Texas fawnsfoot. In addition, we designate critical habitat for all seven species. In total, approximately 1,577.5 river miles (2,538.7 river kilometers) in Blanco, Brown, Caldwell, Coleman, Comal, Concho, DeWitt, Gillespie, Gonzales, Guadalupe, Hays, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, Palo Pinto, Parker, Runnels, San Saba, Shackelford, Stephens, Sutton, Throckmorton, Tom Green, Travis, and Victoria Counties, Texas, fall within the boundaries of the critical habitat designation. This rule applies the protections of the Act to these species and their designated critical habitat (89 FR 48034).

Critical Habitat Designation

We have determined that the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli) meet the Act's definition of endangered species, and the Texas fawnsfoot (Truncilla macrodon) meets the Act's definition of a threatened species; therefore, we are listing them as such, finalizing a rule under section 4(d) of the Act for the Texas fawnsfoot, and designating critical habitat. Both listing a species as an endangered or threatened species and designating critical habitat can be completed only by issuing a rule through the Administrative Procedure Act rulemaking process (5 U.S.C. 551 et seq.). What this document does. This rule makes final the listing of the Guadalupe fatmucket, Texas fatmucket, Guadalupe orb, Texas pimpleback, Balcones spike, and false spike as endangered species, and the Texas fawnsfoot as a threatened species with a rule issued under section 4(d) of the Act (a ''4(d) rule''). In addition, this rule designates critical habitat for all seven central Texas mussel species in 20 units (including 32 subunits) totaling 1,577.5 river miles (2,538.7 river kilometers (km)) on private, State, and Federal property within portions of 31 counties in Texas (89 FR 48034).

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of Texas fatmucket consist of the following components within waters and streambeds up to the ordinary high-water mark:

(i) Flowing water at moderate to high rates with sufficient depth to remain sufficiently cool and oxygenated during low-flow periods

(ii) Substrate including bedrock and boulder crevices, point bars, and vegetated run habitat comprising sand, gravel, and larger cobbles

(iii) Green sunfish (Lepomis cyanellus), bluegill (L. macrochirus), largemouth bass (Micropterus salmoides), and Guadalupe bass (M. treculii) present

(iv) Water quality parameters within the following ranges: (A) Dissolved oxygen greater than 2 milligrams per liter (mg/L); (B) Salinity less than 2 parts per thousand; (C) Total ammonia less than 0.77 mg/ L total ammonia nitrogen; (D) Water temperature below 29 °C (84.2 °F); and (E) Low levels of contaminants

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the central Texas mussels may require special management considerations or protections to reduce the following threats: increased fine sediment, changes in water quality, altered hydrology from both inundation and flow loss/scour, predation and collection, and barriers to fish movement. Management activities that could ameliorate these threats include, but are not limited to: Use of best management practices (BMPs) designed to reduce sedimentation, erosion, and bank side destruction; protection of riparian corridors and retention of sufficient canopy cover along banks; exclusion of livestock and nuisance wildlife (feral hogs, exotic ungulates); moderation of surface and groundwater withdrawals to maintain natural flow regimes; increased use of stormwater management and reduction of stormwater flows into the systems; use of highest water quality standards for wastewater and other return flows; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the occupied areas we are designating as critical habitat contain the PBFs that are essential to the conservation of the species and that may require special management considerations or protection. Special management considerations or protection may be required of the Federal action agency to eliminate, or to reduce to negligible levels, the threats affecting the PBFs of each unit (89 FR 48034).

Life History

Feeding Narrative

Larvae: Larval unionid mussels require a host.

Juvenile: For their first several months, juvenile mussels feed using cilia (fine hairs) on the foot to capture suspended as well as depositional material, such as algae and detritus (Yeager et al. 1994, pp. 253259).

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874876; Christian et al. 2004, p. 109). Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity, when energy presumably is being diverted from growth to reproductive activities (Baird 2000, pp. 6667).

Reproduction Narrative

Adult: Although there is no specific information on age and size of maturity of the Texas fatmucket, it is likely similar to a related species, the Louisiana fatmucket (L. hydiana), which reaches sexual maturity around 36 mm (1.4 in) (Howells 2000b, pp. 3548; Howells 2010c, p. 3). Texas fatmucket females have been found gravid (with glochidia in the gill pouch) from July through October, although brooding may continue throughout much of the year (Howells 2010c, p. 3). Texas fatmucket females display a mantle lure to attract host fish, releasing glochidia when the lure is bitten or struck by the fish. Bluegill (Lepomis macrochirus) and green sunfish (L. cyanellus) have been successful hosts in laboratory studies (Howells 1997b, p. 257). Hosts such as these sunfishes are common, widely distributed species in Texas that occur in an array of habitat types (Hubbs et al. 2008, p. 45) and would not generally be expected to be a limiting factor in Texas fatmucket reproduction and distribution (Howells 2010c, p. 3). Mussels are extremely long lived, living from two to several decades (Rogers et al. 2001, p. 592), and possibly up to 200 years in extreme instances (Bauer 1992, p. 427). Most mussel species, including Texas fatmucket, have distinct forms of male and female. During reproduction, males release sperm into the water column, which females draw in through their siphons. Fertilization takes place internally, and the resulting eggs develop into specialized larvae (called glochidia) within the females modified gill pouch (called marsupia) for 4 to 6 weeks. The females will then release matured glochidia individually, in small groups, or embedded in larger mucus structures called conglutinates. Glochidia are obligate parasites (cannot live independently of their hosts) on fish and attach to the gills or fins of appropriate host species where they encyst (enclose in a cyst-like structure) and feed off of the hosts body fluids (Vaughn and Taylor 1999, p. 913) and develop into juvenile mussels weeks or months after attachment (Arey 1932, pp. 214215). The glochidia will die if they fail to find the appropriate host fish, attach to a fish that has developed immunity from prior infestations, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 299). Mussels experience their primary opportunity for dispersal and movement within the stream as glochidia attached to a host fish (Smith 1985, p. 105). Upon release from the host, newly transformed juveniles drop to the substrate on the bottom of the stream. Those juveniles that drop in unsuitable substrates die because their immobility prevents them from relocating to more favorable habitat. Juvenile freshwater mussels burrow into interstitial substrates and grow to a larger size that is less susceptible to predation and displacement from high flow events (Yeager et al. 1994, p. 220). Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish.

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The Texas fatmucket occurs in moderately sized rivers in mud, sand, or gravel, or mixtures of these substrates (Howells 2010c, p. 4) and sometimes in narrow crevices between bedrock slabs (Howells 1995, p. 21). Live individuals have been found in relatively shallow water, rarely more than 1.5 meters (m) (4.9 feet (ft)) deep, and usually less. Remaining populations typically occur at sites where one or both banks are relatively low, allowing floodwaters to spread out over land and thereby reducing damage from scouring (Howells 2010c, p. 4). Burlakova and Karatayev (2012b, p. 16) conducted a habitat analysis based on recent survey findings, which found that Texas fatmucket typically favored rivers with bedrock characterized by very low water capacity and rapid water permeability that quickly dry during low water and drought events. This is why Texas fatmucket are especially prone to the changes in water regime and water over-extraction (Burlakova and Karatayev 2012b, p. 16). It was once thought that this species was intolerant of impounded waters, man-made or natural. However, surveys in 2012 and 2013 conducted by the U. S. Fish and Wildlife Service (Service), U.S. Geological Surveys (USGS), and Texas Parks and Wildlife Department (TPWD) suggest that Texas fatmucket typically occurs in quiet, slow moving waters in fine silt substrate along the perimeter of impounded waters and in rivers near macrophyte (aquatic plant) growths of which the majority of the water body is made up of bedrock with pool habitat (Service files 2012; 2013).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
unknown

Number of Populations:
9 to 16?

Population Size:
Unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Based on historical and current data, the Texas fatmucket has declined significantly rangewide and has been extirpated from most of the Guadalupe River system and hundreds of miles of the Colorado River, as well as from numerous tributaries. Extant populations are represented by only a few individuals, and they are highly disjunct and restricted to short reaches. Two of the sites known to harbor Texas fatmucket in recent years may no longer support this species, and the remaining seven sites harbor few individuals and are likely not stable. No evidence of recent recruitment has been found in any of the sites, with the possible exception of the Llano River. The Texas fatmucket has been considered a species of special concern by some malacologists for several decades (Athearn 1970, p. 28).

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:

Narrative: A major factor in the decline of freshwater mussels across the United States has been the large-scale impoundment of rivers (Vaughn and Taylor 1999, p. 913). Dams are the source of numerous threats to freshwater mussels: They block upstream and downstream movement of species by blocking host fish movement; they eliminate or reduce river flow within impounded areas, thereby trapping silts and causing sediment deposition; and dams change downstream water flow timing and temperature, decrease habitat heterogeneity, and affect normal flood patterns (Layzer et al. 1993, pp. 6869; Neves et al. 1997, pp. 6364; Watters 2000, pp. 261264; Watters 1996, p. 80). Within reservoirs (the impounded waters behind dams), the decline of freshwater mussels has been attributed to sedimentation, decreased dissolved oxygen, and alteration of resident fish populations (Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 261264). Dams significantly alter downstream water quality and stream habitats (Allan and Flecker 1993, p. 36; Collier et al. 1996, pp. 1, 7) resulting in negative effects to tailwater (the area downstream of a dam) mussel populations (Layzer et al. 1993, p. 69; Neves et al. 1997, p. 63; Watters 2000, pp. 265266). Below dams, mussel declines are associated with changes and fluctuation in flow regime, scouring and erosion of stream channels, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Williams et al. 1992, p. 7; Layzer et al. 1993, p. 69; Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 265266). Numerous dams have been constructed throughout the Colorado and Guadalupe-San Antonio River systems within the range of Texas fatmucket (Stanley et al. 1990, p. 61).

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Siltation and general sediment runoff is a pervasive problem in streams and has been implicated in the decline of stream mussel populations (Ellis 1936, pp. 3940; Vannote and Minshall 1982, p. 4105; Dennis 1984, p. ii; Brim Box and Mossa 1999, p. 99; Fraley and Ahlstedt 2000, pp. 193194). Specific biological effects on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills (Ellis 1936, p. 40), disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity (Marking and Bills 1979, pp. 208209; Vannote and Minshall 1982, p. 4106), physical smothering, and disrupted host fish attractant mechanisms (Hartfield and Hartfield 1996, p. 373). The primary effects of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999, p. 101). The physical effects of sediment on mussel habitats are multifold and include changes in suspended material load; changes in streambed sediment composition from increased sediment production and runoff in the watershed; changes in the form, position, and stability of stream channels; changes in water depth or the width-to-depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave mussels stranded (Brim Box and Mossa 1999, pp. 109112).

Stressor: Dewatering
Exposure:
Response:
Consequence:
Narrative: River dewatering can occur in several ways: Anthropogenic activities such as surface water diversions and groundwater pumping, and natural events, such as drought. Surface water

diversions and groundwater pumping can lower water tables, reducing river flows and reservoir levels. When water levels in streams and reservoirs are lowered dramatically, it can result in mussels being stranded and dying in previously wetted areas. This is a particular concern within and below reservoirs where water levels are managed for purposes that result in water levels in the reservoir or downstream to rise or fall in very short periods of time, such as when hydropower facilities release water during peak energy demand periods. Rivers can also be dewatered to expedite construction activities, which happened in the upper Guadalupe River in Kerr County in 1998 for bridge construction; numerous Texas fatmuckets were exposed and desiccated (dried out and died) (Howells 1999, pp. 1819).

Stressor: Sand and Gravel Mining
Exposure:
Response:
Consequence:
Narrative: Sand and gravel mining (removing bed materials from streams) has been implicated in the destruction of mussel populations across the United States (Hartfield 1993, pp. 136138). Sand and gravel mining causes stream instability by increasing erosion and turbidity (a measure of water clarity) and causing subsequent sediment deposition downstream (Meador and Layher 1998, pp. 89). These changes to the stream can result in large-scale changes to aquatic fauna, by altering habitat and affecting spawning of fish, mussels, and other aquatic species (Kanehl and Lyons 1992, pp. 411). Sedimentation and increased turbidity can accrue from instream mining activities. In the Brazos River, a gravel dredging operation was documented as depositing sediment as far as 1.6 km (1 mi) downstream (Forshage and Carter 1973, p. 697). Accelerated streambank erosion and downcutting of streambeds are common effects of instream sand and gravel mining, as is the mobilization of fine sediments during sand and gravel extraction (Roell 1999, p. 7).

Stressor: Chemical Contaminants
Exposure:
Response:
Consequence:
Narrative: Chemical contaminants are ubiquitous throughout the environment and are a major reason for the decline of freshwater mussel species nationwide (Richter et. al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007a, p. 2029). Chemicals enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal effluents, and agriculture runoff. These sources contribute organic compounds, heavy metals, pesticides, herbicides, and a wide variety of newly emerging contaminants to the aquatic environment. As a result, water quality can be degraded to the extent that mussel populations are adversely affected.

Stressor: Predation
Exposure:
Response:
Consequence:
Narrative: Raccoons will prey on freshwater mussels stranded by low waters or deposited in shallow water or on bars following flooding or low water periods (Howells 2010c, p. 12). Predation of Texas fatmucket by raccoons may be occurring occasionally, but there is no indication it is a significant threat to the status of the species. Some species of fish feed on

mussels, such as common carp, freshwater drum, and redear sunfish, all of which are common throughout the range of Texas fatmucket (Hubbs et al. 2008, pp. 19, 45, 53). Common species of flatworms are voracious predators of newly metamorphosed juvenile mussels of many species (Zimmerman et al. 2003, p. 30). Predation is a normal factor influencing the population dynamics of a healthy mussel population; however, predation may amplify declines in small populations primarily caused by other factors.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: Despite some State and Federal laws protecting the species and water quality, the Texas fatmucket continues to decline due to the effects of habitat destruction, poor water quality, contaminants, and other factors. The regulatory measures described above are not sufficient to significantly reduce or remove the threats to the Texas fatmucket. Based upon our review of the best commercial and scientific data available, we conclude that the lack of existing regulatory mechanisms is an immediate threat of moderate magnitude to the Texas fatmucket.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Climate change could affect the Texas fatmucket through the combined effects of global and regional climate change, along with the increased probability of long-term drought. Climate change exacerbates threats such as habitat degradation from prolonged periods of drought, increased water temperature, and the increased allocation of water for municipal, agricultural, and industrial use. As such, climate change, in and of itself, may affect the Texas fatmucket, but the magnitude and imminence (when the effects occur) of the effects remain uncertain. Based upon our review of the best commercial and scientific data available, we conclude that the effects of climate change in the future will likely exacerbate the current and ongoing threats of habitat loss and degradation caused by other factors.

Stressor: Population Fragmentation and Isolation
Exposure:
Response:
Consequence:
Narrative: All of the remaining populations of the Texas fatmucket are small and geographically isolated and thus are susceptible to genetic drift (change of gene frequencies in a population over time), inbreeding depression, and random or chance changes to the environment, such as toxic chemical spills (Watters and Dunn 1995, pp. 257 258) or dewatering. Inbreeding depression can result in death, decreased fertility, smaller body size, loss of vigor, reduced fitness, and various chromosomal abnormalities (Smith 1974, pp. 350). Despite any evolutionary adaptations for rarity, habitat loss and degradation increase a species vulnerability to extinction (Noss and Cooperrider 1994, pp. 5862). Numerous authors (including Noss and Cooperrider 1994, pp. 5862; Thomas 1994, p. 373) have indicated that the probability of extinction increases with decreasing habitat availability. Although changes in the environment may cause populations to fluctuate naturally, small and low-density populations are more likely to fluctuate below a minimum viable population (the minimum or threshold number of individuals needed in a population to persist in

a viable state for a given interval) (Gilpin and Soule 1986, pp. 2533; Shaffer 1981, p. 131; Shaffer and Samson 1985, pp. 148 150).

Stressor: Nonnative Species
Exposure:
Response:
Consequence:
Narrative: Various nonnative species of aquatic organisms are firmly established within the range of the Texas fatmucket and pose a threat to the species. Golden algae (Prymnesium parvum) is a microscopic algae considered to be one of the most harmful algal species to fish and other gill-breathing organisms (Lutz-Carrillo et al. 2010, p. 24). Golden algae was first discovered in Texas in 1985 and is presumed to have been introduced from western Europe (Lutz- Carrillo et al. 2010, p. 30). Since its introduction, golden algae has been found in Texas rivers and lakes, including two lakes in central Texas (Baylor University 2009, p. 1). Under certain environmental conditions, this algae can produce toxins that can cause massive fish and mussel kills (Barkoh and Fries 2010, p. 1; Lutz-Carrillo et al. 2010, p. 24). Evidence shows that golden algae probably caused fish kills in Texas as early as the 1960s, but the first documented fish kill due to golden algae in inland waters of Texas occurred in 1985 on the Pecos River in the Rio Grande basin (TPWD 2002, p. 1). The range of golden algae has increased to include portions of the Brazos and Colorado River basins, among others, and it has been responsible for killing more than 8 million fish in the Brazos River since 1981 and more than 2 million fish in the Colorado River since 1989 (TPWD 2010a, p. 1). Although actual mussel kills in Texas due to golden algae have not been recorded in the past, the toxin can kill mussels. Therefore, the elimination of host fish and the poisonous nature of the toxin to mussels make future golden algae blooms a threat to the Texas fatmucket. An additional nonnative species, the zebra mussel (Dreissena polymorpha), poses a potential threat to the Texas fatmucket. This invasive species has been responsible for the extirpation of freshwater mussels in other regions of the United States, including the Higgins eye (Lampsilis higginsii) in Wisconsin and Iowa (Service 2006, pp. 910). Zebra mussels attach in large numbers to the shells of live native mussels and are implicated in the loss of entire native mussel beds (Ricciardi et al. 1998, p. 615). This fouling impedes locomotion (both laterally and vertically), interferes with normal valve movements, deforms valve margins, and essentially suffocates and starves the native mussels by depleting the surrounding water of oxygen and food (Strayer 1999, pp. 7780). Heavy infestations of zebra mussels on native mussels may overly stress the animals by reducing their energy reserves. Zebra mussels may also filter the sperm and possibly glochidia of native mussels from the water column, thus reducing reproductive potential. Habitat for native mussels may also be degraded by large deposits of zebra mussel pseudofeces (undigested waste material passed out of the incurrent siphon) (Vaughan 1997, p. 11). Zebra mussels are not currently found within the range of the Texas fatmucket. However, a live adult zebra mussel was first documented in Lake Texoma on the Red River (on the north Texas border with Oklahoma) in 2009 (TPWD 2009a, p. 1). Since that time, additional zebra mussels have been reported from Lake Texoma, where they are now believed to be well established (TPWD 2009c, p. 1). New studies looking for the presence of zebra mussel DNA and zebra mussel larvae (veligers) within 14 north Texas reservoirs revealed that zebra mussel DNA was present in six of those reservoirs; however, none of those reservoirs contained veliger larvae, which suggests that zebra mussels have not become established in those lakes (TPWD 2011, p. 1). To date, Lake Texoma is the only reservoir known to harbor zebra mussels from all life stages. Zebra mussels are likely to spread to many other Texas reservoirs through accidental human transport (Schneider et al. 1998, p. 789). Although zebra mussels tend to proliferate in reservoirs or large pools, released zebra mussel

veligers float downstream and attach to any hard surface available, rendering downstream Texas fatmucket populations extremely vulnerable to attachment and fouling. Because zebra mussels are so easily introduced to new locations, the potential for zebra mussels to continue to expand in Texas and invade the range of the Texas fatmucket is high. If this occurs, the Texas fatmucket is vulnerable to zebra mussel attachment and subsequent deprivation of oxygen, food, and mobility. A molluscivore (mollusk eater), the black carp (Mylopharyngodon piceus) is a potential threat to the Texas fatmucket. The species has been commonly used by aquaculturists to control snails or for research in fish production in several States, including Texas (72 FR 59019, October 18, 2007). Black carp can reach more than 1.3 m (4 ft) in length and 150 pounds (68 kilograms (kg)) (Nico and Williams 1996, p. 6). Foraging rates for a 4-year old fish average 3 to 4 pounds (1.4 to1.8 kg) a day, indicating that a single individual could consume 10 tons (9,072 kg) of native mollusks over its lifetime (Mississippi Interstate Cooperative Resource Association (MICRA) 2005, p. 1). Black carp can escape from aquaculture facilities. For example, in 1994 30 black carp escaped from an aquaculture facility in Missouri during a flood. Other escapes into the wild by non-sterile carp are likely to occur. Because of the high risk to freshwater mussels and other native mollusks, the Service recently listed black carp as an injurious species under the Lacey Act (72 FR 59019, October 18, 2007), which prevents importations and interstate transfer of this harmful species, but does not prevent its release into the wild once it is in the State. If the black carp were to escape within the range of the Texas fatmucket, it would likely negatively affect native mussels, including the Texas fatmucket. Based upon our review of the best commercial and scientific data available, we conclude that golden algae is an ongoing threat to the Texas fatmucket, and other nonnative species, such as zebra mussels and black carp, are a potential future threat to the Texas fatmucket that is likely to increase as these exotic species expand their occupancy within the range of the Texas fatmucket.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- The Texas fatmucket is listed as threatened by the TPWD in Texas and is a high priority species in the Texas Wildlife Action Plan 2005-2010 (TPWD 2005, p. 756). The Service, TPWD, academia, and other resource agencies have proposed and ongoing studies in Texas river systems for Texas freshwater mussels, including the Texas fatmucket, observing life history parameters (including determination of ecological fish hosts), survivability of juveniles, monitoring habitat, and analyzing population dynamics. In addition, TPWD has established a Mussel Watch group.
- The Service is currently working on forming and implementing the use of a Strategic Conservation Plan for Texas Freshwater Mussels that will result in additional conservation measures such as, best management practices, survey protocols, relocation protocols, and monitoring guidelines. The Service will be collaborating with other Federal, State, and non-governmental agencies during the formation and implementation of the Strategic Conservation Plan.

- Continued survey and monitoring efforts are needed throughout former and occupied sites to better define the species distribution and status in the Colorado and Guadalupe-San Antonio River systems.
- Continued biological and ecological research efforts are needed to identify host fish, spawning and brooding seasons, glochidia, and habitat and physiochemical parameters for Texas fatmucket. The Service will continue to work with TPWD, United States Geological Surveys (USGS), and others needed research in order to facilitate the conservation and preservation of the Texas fatmucket.
- The Service will continue working with resource management agencies and academia on developing a drought contingency plan that will facilitate the management and monitoring of mussel populations that harbor species of concern (i.e. the Texas fatmucket) during times of drought.
- The Service will continue working with resource management agencies, TxDOT, and academia on the development of standard mussel survey, relocation, and monitoring protocols, which would establish a commonality among the wide variety of methods currently being used in Texas and would establish a baseline of what kind of data needs to be collected while conducting surveys.
- Long-term conservation measures need to be developed to facilitate and accomplish cooperative efforts between resource management agencies and private landowners. The development of candidate conservation agreements (with assurances) with interested parties would initiate conservation for the Texas fatmucket.
- The Service will continue working with resource management agencies and the Texas Department of Transportation (TxDOT) on developing best management practices for proposed adjacent/instream impacts specific to Texas water systems.

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2014. USFWS. 2021. Proposed Rule. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. FR Vol. 86, No. 163. Pages 47916- 48011.

89 FR. No. 108. Pages 48034-48130. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, Balcones Spike, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. Final Rule.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2019

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2020

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2021

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2022

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2023

SPECIES ACCOUNT: *Lampsilis higginsii* (Higgins eye (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

A freshwater mussel with the following shell characteristics: Oval or elliptical, somewhat inflated, solid, with gaping anterior base; beaks placed forward of the center of the dorsal margin, much elevated, swollen, their sculpture consisting of a few feeble ridges slightly looped; anterior end broadly rounded; posterior end truncated in the female, bluntly pointed in the male; ventral and dorsal margins slightly curved, almost parallel; posterior ridge rounded, but well marked; surface shining, marked by irregular growth lines which are better developed at rest periods where they are usually dark colored; epidermis olive or yellowishgreen with faint green rays. Hinge massive; pseudocardinals erect, triangular or pyramidal, divergent, serrated, two in the left and one in the right valve, with sometimes indications of additional denticles on either side of the single right pseudocardinal; interdentium narrow, flat; laterals short, thick, slightly curved, almost smooth; cavity of the beaks deep, containing the dorsal muscle scars; anterior adductor scar deeply excavated, posterior scar distinct; nacre silverywhite, iridescent, often tinged with pink."

Taxonomy

A number of species can be confused with L. higginsii. Those cited as most similar are Obovaria olivaria, L. cardium, L. siliquoidea, L. abrupt and Actinonaias ligamentina (Baker 1928; Cummings and Mayer 1992).

Historical Range

The historic distribution of L. higginsii before 1965 was given as the main stem of the Mississippi River from just north of St. Louis, Missouri, to just south of St. Paul, Minnesota; in the Illinois, Sangamon, and Rock Rivers in Illinois; in the Iowa, Cedar, and Wapsipinicon Rivers in Iowa; in the Wisconsin and St. Croix rivers in Wisconsin; and, in the Minnesota River in Minnesota (based on Havlik 1980). A questionable report of this species in the lower Ohio River was also given (Havlik 1980). The initial plan also indicated a great reduction in the range of L. higginsii based on studies from 1965 through 1981 (Larsen and Holzer 1978; Mathiak 1979; Perry 1979; Havlik 1980; Fuller 1980; Thiel et al. 1980; Thiel 1981; Ecological Analysts 1981a). Since the 1983 Recovery Plan, a number of studies have provided new information on the distribution and abundance of L. higginsii. A study by Cawley (1996) commissioned by the USFWS for the current recovery team provided a review of the information on L. higginsii distribution from 1980-1996. Cawley (1996) noted that 510 specimens of L. higginsii had been collected since 1980. Cawley (1996) extended the reported range of L. higginsii 98 miles to the south and 82 miles to the north based on the collection of dead specimens. There is some uncertainty regarding the historical distribution of Higgins eye but it is believed to have been distributed widely, inhabiting the Upper Mississippi River main stem from just north of St. Louis, Missouri, to Minneapolis-St. Paul, Minnesota (Coker 1919). It also was found in several Upper Mississippi River tributaries including the Ohio, Illinois, Sangamon, Iowa, Cedar, Wapsipinicon, Rock, Wisconsin, Black, Minnesota, St. Croix Rivers (USFWS 2004), and the Chippewa River in Wisconsin (USFWS 2018, p. 6).

Current Range

The Higgins eye occurs in Illinois, Iowa, Minnesota, South Dakota, and Wisconsin. The range of Higgins eye has been reduced from its historical distribution and now includes the Upper Mississippi River upstream of Lock and Dam 22 near Hannibal, Missouri, the lower St. Croix River between Wisconsin and Minnesota, 59 the lower Wisconsin River, Wisconsin, and the lower Rock River in Illinois (USFWS 2004). The species has been recently reintroduced to two locations on the Chippewa River in Wisconsin (Smith 2018, p. 1), although it is too soon to determine whether these efforts have resulted in the successful reestablishment of the species in those areas. Higgins eye is present in Effigy Mounds National Monument, Mississippi National River Recreation Area, Missouri National Recreational River, and Saint Croix National Scenic Riverway. (USFWS, 2020)

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Males release sperm into the water, often in packets known as volvocoid bodies (Fuller 1974) that are taken in through the incurrent siphon by the female. Fertilization occurs and zygotes are brooded in the water tubes of the gills by the female. In the genus Lampsilis, the marsupia that contain the glochidia, are kidney-shaped, occupying the posterior portion of the outer gills. Female unionids can produce up to a million eggs a year (Burky 1983). The zygotes develop into larvae (glochidia) that are released into the water column in various ways. In the genus Lampsilis, the edge of the mantle of the female develops into a ribbon-like flap in front of the branchial opening. This flap has been described as “minnow-like” in appearance, often having a dark “eye-spot,” and thus it has been suggested to be important in attracting fish hosts (Baker 1928). The glochidia attach to a fish host, where they remain for approximately three weeks (at water temperatures of 20-22oC) (D. Waller, U.S. Geological Survey, pers. comm.) as they transform into juveniles. They then drop off their fish host, develop a byssal thread, which may assist in dispersal, and upon settling on suitable habitat, use the byssal thread as a means of attachment, to prevent being swept away in water currents. Lampsilis higginsii is a long-term brooder (bradytictic). This means that they spawn in the summer and larvae are retained in the marsupia through the winter until they are released the following spring/summer. Glochidial release has been reported during June and July (Waller and Holland-Bartels 1988) and May and September (Surber 1912). Glochidia of L. higginsii are morphologically similar to those of several other species of lampsilines in the Upper Mississippi River. Waller and Mitchell (1988) have shown that Lampsilis higginsii glochidia can be differentiated from L. cardium, L. siliquoidea, and Ligumia recta by electron microscopy; they could not be differentiated by light microscopy or morphometric measures. Early studies indicated that the sauger (Stizostedion canadense) and freshwater drum (Aplodinotus grunniens) were fish hosts for glochidia of L. higginsii (Surber 1912; Wilson 1916; Coker et al. 1921). These identifications were based on examination of natural infestations, but field identifications are not robust (Waller and Holland-Bartels 1988; Waller and Mitchell 1988); Hove and Kapuscinski (2002), however, confirmed sauger as a suitable host. Based on laboratory infestations of fish with L. higginsii glochidia, Waller and Holland-Bartels (1988) indicated that four species of fish were suitable hosts: largemouth bass (Micropterus salmoides), smallmouth bass (M. dolomieu), walleye (Stizostedion vitreum vitreum) and yellow perch (Perca flavescens). There was some transformation of glochidia to juveniles on green sunfish (Lepomis cyanellus), whereas two species, bluegill (Lepomis macrochirus) and northern pike (Esox lucius), were considered marginal hosts, because each produced only one juvenile. The common carp (Cyprinus carpio) and fathead minnow (Pimephales promelas) were unsuitable hosts. Studies by Waller and Holland-Bartels (1988) and Waller and Mitchell (1988) supported those by Sylvester et al. (1984) that walleye and largemouth bass were hosts for L. higginsii, but Sylvester et al. (1984) indicated that the green sunfish and bluegill were not suitable hosts. Hove and Kapuscinski (2002) confirmed largemouth bass as suitable hosts and found that sauger and black crappie also facilitated metamorphosis of L. higginsii glochidia. In general, Waller and Holland-Bartels (1988) indicate that percids and centrarchids are suitable hosts, whereas cyprinids, ictalurids and catostomids are unsuitable. Neves and Widlak (1988) also indicated that members of the subfamily Lampsilinae were more likely to be found on centrarchids and percids than on cyprinids and cottids.

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Lampsilis higginsii is characterized as a large river species occupying stable substrates that vary from sand to boulders, but not firmly packed clay, flocculent silt, organic material, bedrock, concrete or unstable sand. Water velocities should be less than 1 m/second during periods of low discharge. They are usually found in mussel beds that contain at least 15 other species at densities greater than .01 individual/m2. In the Mississippi River, the density of all mussels in the bed typically exceeds 10/m2. Since listing, almost all of the extant sites have had encroachment of zebra mussels. Only the Chippewa River and Interstate populations have not experienced zebra mussel encroachment (USFWS, 2020).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

6 to 20

Population Size:

100,000 to 1,000,000 individuals

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Population Narrative:

Since the initial listing of the species, a variety of authors have noted declines in mussel populations within the range of L. higginsii. The Higgins eye population in the Mississippi River at Prairie du Chien, Wisconsin, has crashed as a result of skyrocketing zebra mussel populations at that site. What was once the stronghold for the species now holds only a few pockets of Higgins eye, while the main portions of the habitat at this site now consist of layers of zebra mussel shells. As a result, the population in the Mississippi River at Cordova, Illinois, is likely the stronghold for the species.Genetic analysis within and between Higgins eye populations was completed recently (Bowen 2004). Higgins eye populations exhibit no differentiation among populations but show a wide range of genetic variation within populations, indicating that while there is a high degree of variability between individuals, the populations do not differ from each other. The northern most population (in the St. Croix River at Hudson, Wisconsin) exhibited less genetic variation than the southern populations, likely due to its relatively recent establishment after the last glaciated period (Bowen 2004). Due to the high degree of genetic variability within populations, Bowen (2004) recommends that glochidia from at least 100 donor females be used to establish each new population. There is some uncertainty regarding the historical distribution of Higgins eye but it is believed to have been distributed widely, inhabiting the Upper Mississippi River main stem from just north of St. Louis, Missouri, to Minneapolis-St. Paul, Minnesota (Coker 1919). It also was found in several Upper Mississippi River tributaries including the Ohio, Illinois, Sangamon, Iowa, Cedar, Wapsipinicon, Rock, Wisconsin, Black, Minnesota, St. Croix Rivers (USFWS 2004), and the Chippewa River in Wisconsin (USFWS 2018, p. 6). The range of Higgins eye has been reduced from its historical distribution and now includes the Upper Mississippi River upstream of Lock and Dam 22 near Hannibal, Missouri, the lower St. Croix River between Wisconsin and Minnesota, 59 the lower Wisconsin River, Wisconsin, and the lower Rock River in Illinois (USFWS 2004). The species has been recently reintroduced to two locations on the Chippewa River in Wisconsin (Smith 2018, p. 1), although it is too soon to determine whether these efforts have resulted in the successful reestablishment of the species in those areas. (USFWS 2021)

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: Population losses due to impoundments, particularly the locks and dams on the Mississippi River used for commercial navigation, have probably contributed greatly to the decline and imperilment of Higgins eye. Dams impound large river habitats throughout nearly the entire range of the species. These impoundments have left short and isolated patches of remnant habitat, typically just downstream of the dams. Dams impound most of the upper Mississippi River and many of its tributaries; this system encompasses the stronghold for the Higgins eye.

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Interstitial spaces within stream substrates provide crucial habitat for juvenile mussels. When fine sediments deposit in these spaces, interstitial flow and habitat space for juveniles are reduced or eliminated (Brim Box and Mossa 1999). Fine sediments may also act as a vector for the delivery of contaminants, such as nutrients and pesticides. These may be important factors inthe recruitment failures of mussel populations, including those of Higgins eye. Intermittent exposure of freshwater mussels (Quadrula quadrula, Pleurobema beadleanum,

and Fusconaia cerina) to 600 – 750 mg/L of suspended solids adversely affects feeding rate, oxygen uptake, and excretion (Aldridge et al. 1987), although concentrations of this magnitude are not expected tooccur with any regularity in the St. Croix or upper Mississippi Rivers. As Higgins eye tend to inhabit relatively deep water, they may be particularly vulnerable to siltation. The current is slower in this habitat than in riffles and runs, and suspended sedimentsettles out. However, since they are adapted to these slower currents, they may not be as sensitive to normal, ambient levels of sedimentation as more intolerant species that inhabit riffles and runs. Siltation has resulted in increased turbidity levels in many midwestern streams. During reproduction, Higgins eye display a mantle lure that resembles a minnow and appears to attractpotential hosts. The success of this reproductive strategy depends on water clarity when Higgins eye are displaying, because fish hosts are likely to be attracted visually to the display (Hartfield and Hartfield 1996). Increased turbidity levels also may reduce production of food for Higgins eye by reducing solar energy in the water column (Kanehl and Lyons 1992). Dredging or other activities that destabilize instream fine sediments are likely to affect Higgins eye adversely. Dredging to maintain barge traffic on the Mississippi River below the mouth of the Chippewa River in Wisconsin, for example, has reduced mussel diversity due to the increase in unstable sand substrates (Thiel 1981). Lake Pepin, a once natural lake formed in the upper Mississippi River upstream from the mouth of the Chippewa River, has become increasingly silted over the past century, reducing habitat for Higgins eye and other mussels (Thiel 1981). Agricultural activities are responsible for most of the sediment that enters streams (Waters 1995),including both sediment and chemical run off; agriculture affects 72 percent of the impaired river miles in the country (Neves et al. 1997). Grazing may lead to a reduction in infiltration rates and an increase in runoff; moreover, trampling and removal of vegetation reduces resistance of banks to erosion (Armour et al. 1991, Trimble and Mendel 1995, Brim Box and Mossa 1999).Mississippi River tributaries in the southern portion of Higgins eye's range (e.g., Iowa and Illinois) have been particularly affected by agricultural activities.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: As benthic filter-feeding organisms, freshwater mussels are exposed to contaminants dissolved in water, associated with suspended particles, and deposited to bottom sediments. Thus, freshwater mussels can bioaccumulate contaminants to concentrations that exceed those in contaminated water or sediments. The effects of contaminants are especially profound on juvenile mussels (Robison et al. 1996), which readily ingest contaminants adsorbed to sediment particles while feeding, and onglochidia, which appear to be very sensitive to toxicants (Goudreau et al. 1993, Jacobson et al. 1997). Mussels are very intolerant of heavy metals (Keller and Zam 1991, Havlik and Marking 1987), and even at low levels, certain heavy metals may inhibit glochidial attachment to fish hosts (Huebner and Pynnönen 1992). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also adversely affect biological processes (Naimo 1995, Keller and Zam 1991, Jacobson et al. 1997, Keller and Lydy 1997). Among pollutants, ammonia has been shown to be lethal to adult and juvenile mussels at concentrations of 2.5 ppm (Augsperger et al. 2003), which is substantially less than the national water quality criterion. Ammonia is oftentimes associated with animal feedlots, industrial waste, nitrogenous fertilizers, and the effluents of out-dated municipal wastewater treatment plants that do not control ammonia (Goudreau et al. 1993, Augspurger et al. 2003). In streams, ammonia is most prevalent at the substrate/water

interface (Frazier et al. 1996). Due to its high level of toxicity and the occurrence of the highest concentrations in the microhabitats where mussels live, ammonia may be limiting mussel populations at some locations (Augspurger et al. 2003, Bartsch et al. 2003). Ammonia sources include industrial, municipal, and agricultural sources, precipitation, and natural processes (Newton 2003). Although recent data suggest that mussels are generally more sensitive to ammonia than fishes, effects of ammonia on host fishes is also a potential threat to the persistence of Higgins eye populations. Mean acute levels of ammonia for two marginal host species (green sunfish and bluegill) and three suitable host species (largemouth bass, smallmouth bass, and walleye) ranged from 20 to 35 ppm, which is higher than the toxic level for juvenile mussels. Contaminants associated with households and urban areas, particularly those from industrial and municipal effluents, may include heavy metals, chlorine, phosphorus, and numerous organic compounds. Wastewater is discharged through National Pollution Discharge Elimination System (NPDES) permitted (and some non-permitted) sites throughout the country. Elimination sites are common throughout the range of Higgins eye. Agricultural sources of chemical contaminants are considerable and include two broad categories: nutrient enrichment (e.g., runoff from livestock farms and feedlots, fertilizers from row crops) and pesticides (e.g., from row crops) (Frick et al. 1998). Nitrate concentrations areparticularly high in surface waters downstream of agricultural areas (Mueller et al. 1995). Fertilizers and pesticides also are used commonly in developed areas. These contaminants have the potential to impact all extant populations of Higgins eye.Little is known about the effects of organic contaminants on freshwater mussels, but the available data suggest some compounds in the upper Mississippi River have the potential to harm Higgins eye and to degrade entire benthic invertebrate communities. For example, zebra mussels have been shown to bioaccumulate substantial quantities of polychlorinated biphenyls (PCBs) in the upper Mississippi River (M. R. Bartsch, U.S. Geological Survey, pers. com.). In addition, a survey of PCBs in emergent mayflies identified two zones of concern regarding PCB contamination in riverine sediments: Pools 2 through 6 and Pool 15 of the upper Mississippi River (Steingraeber et al. 1994). Toxic chemical spills have killed mussels and fish throughout the range of Higgins eye, particularly in the Mississippi River where officials have documented several spills, the most recent on March 19, 2005, when a train derailment along the Mississippi River near Cottage Grove, Minnesota, spilled an estimated 2,000 pounds of granular potassium chloride (potash) (Keis 2005). Chemical spills likely will continue to occur and have the potential to eliminateHiggins eye populations completely from river reaches and, possibly, entire rivers.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: Most states with extant Higgins eye populations prohibit the taking of mussels for scientific purposes without a state collecting permit, although some states may find it difficult to enforce this requirement. Furthermore, state regulations generally do not protect mussels from other threats that may be likely to harm habitats and populations incidentally (i.e., upstream dock or fleeting area construction). Sedimentation continues to be an issue throughout the range of Higgins eye. The authority of theClean Water Act to regulate sedimentation has not been sufficient to ameliorate this threat to the species.

Stressor: Non-native species
Exposure:

Response:
Consequence:
Narrative: Various alien or nonnative species of aquatic organisms are established firmly in the range of Higgins eye. The alien species that poses the most significant threat to the Higgins eye is the zebra mussel. Its invasion of freshwater habitats in the United States poses a threat to mussel faunas in many regions (Ricciardi et al. 1998). Strayer (1999) reviewed in detail the mechanisms in which zebra mussels impact native mussels. The primary means of impact is direct fouling of the shells; zebra mussels attach in large numbers to the shells of live native mussels and other hard relatively stable substrates and may destroy entire mussel beds. The impacts of fouling include impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, locally depleting food resources and oxygen, and increasing waste products. Heavy infestations of zebra mussels on native mussels may stress the animals by reducing their energy stores. They may also reduce food concentrations to levels too low to allow for survival and reproduction. Zebra mussels also may impede reproduction of unionids by filtering sperm and larvae from the water column. Large deposits of zebra mussel pseudofeces also may degrade habitat for native mussels by, for example, reducing dissolved oxygen concentrations (USFWS 1997). Overlapping much of the current range of Higgins eye, zebra mussels are established thoroughly throughout the upper Mississippi and lower St. Croix Rivers. Kelner and Davis (2002) stated that zebra mussels in the Mississippi River from Mississippi River Pool 4 downstream are “extremely abundant and are decimating the native mussel communities.” Huge numbers of dead and live zebra mussels cover the bottom of the river in some localities up to 1-2 inches deep (Havlik 2001), where they have reduced significantly the quality of the habitat with their pseudofeces (S.J. Fraley, NCWRC, pers. comm., 2000). From 1993 to 1994, nearly a ten-fold increase in zebra mussel densities occurred in Mississippi River pool 10 at Prairie du Chien (Clarke and Loter 1995), which had been the largest and most productive population of Higgins eye until zebra mussel infestation. Zebra mussels have reduced Higgins eye populations throughout the Mississippi River’s heavily infested waters. Zebra mussels are most likely to affect Higgins eye populations adversely in big rivers, large tributaries, and below infested reservoirs and are likely to continue to spread to additional streams in the foreseeable future. Zebra mussel densities have declined recently at several essential habitat areas for Higgins eye. In the Mississippi River at Prairie du Chien, densities of zebra mussels have gone from 9,390 individuals/m2 in 2000 to 30.7 individuals/m2 in 2003 (U.S. Army Corps of Engineers, unpubl. data). Other populations exhibited similar population crashes during the same time period. Although it appears the zebra mussel populations are at low, stable levels, the populations are likely to increase again in the future; these areas are not protected from future zebra mussel impacts. In 2005, densities increased to 251 individuals/m2 (U.S. Army Corps of Engineers, unpubl. data), indicating a possible increasing trend, although future monitoring will occur to confirm this. The Asian clam (Corbicula fluminea) has spread throughout the Mississippi River system since its introduction into the basin in the mid-1900s. This species has been implicated as a competitor with native mussels for resources such as food, nutrients, and space, particularly as juveniles (Neves and Widlak 1987). Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles (Strayer 1999, Yeager et al. 2001). Additionally, they may disturb sediments, thereby reducing habitat for juvenile native mussels. Periodic die offs may produce enough ammonia and consume enough oxygen to kill native mussels (Strayer 1999). Specific impacts to native unionids, however, remain largely unresolved (Leff et al. 1990, Strayer 1999). A molluscivore, the black carp (Mylopharyngodon piceus) is a potential threat to native unionids (Strayer 1999); it has been introduced into North America since the 1970s. The species has been proposed for widespread

use by aquaculturists to control snails, the intermediate host of a trematode (flatworm) parasite that affects catfish in ponds in the southeast and lower midwest. Black carp are known to eat clams (Corbicula spp.) and unionid mussels in China, in addition to snails. They are the largest of the Asian carp species, reaching more than four feet in length and achieving a weight in excess of 150 pounds (Nico and Williams 1996). In 1994, 30 black carp escaped from an aquaculture facility in Missouri during a flood, although none of the escapees have been found elsewhere. However, given past history and the frequency of flooding and other natural disasters in the southern states in which black carp are held, other escapes into the wild by non-sterile black carp are likely to occur. Escaped black carp are likely to escape and thrive in the wild with or without reproduction. If the escapees were able to reproduce, they would quickly spread throughout the waters of the United States as there are no known limiting factors to prevent their establishment. The common carp (Cyprinus carpio), widespread throughout the Mississippi River basin, may eat juvenile mussels opportunistically. Field observations in the upper Mississippi River have indicated that predation by common carp may be a larger factor in juvenile recruitment than previously thought. The effects of this potential threat are currently under study. Since the last review, non-native carp (e.g., black carp) have expanded their distribution within the range of Higgins eye. Black carp are known molluscivores, but the extent to which they prey on Higgins eye is not known. (USFWS 2020)

Stressor: Population Fragmentation and Isolation
Exposure:
Response:
Consequence:
Narrative: Most of the remaining Higgins eye populations are isolated and thus are susceptible to extirpation from catastrophic events, such as toxic chemical spills. Even if habitats retain or recover their ability to support Higgins eye after such events, natural recolonization of isolated habitats is unlikely. Population isolation also reduces or eliminates gene flow among local populations. This isolation in combination with small effective population size can lead to inbreeding depression within populations (Avise and Hambrick 1996). Higgins eye are relatively long-lived. Therefore, it may take decades for non-reproducing populations to become extinct following their isolation by, for example, the construction of a dam. Small isolated populations that may now be comprised predominantly of adult specimens could be dying out slowly in the absence of recruitment, even without other the threats described above. In reality, however, isolated populations usually face other threats that result in continually decreasing population size (Fahrig and Merriam 1985).

Recovery

Reclassification Criteria:
1. Higgins eye may be considered for reclassification from Endangered to Threatened when at least five identified Essential Habitat Areas contain reproducing, self-sustaining populations of Higgins eye that are not threatened by zebra mussels. The five Essential Habitat Areas must meet the above criteria and must include the Prairie du Chien Essential Habitat Area and at least one Essential Habitat Area each in the St. Croix River and in Mississippi River Pool 14.

a. Higgins eye populations will be considered to be “reproducing” if there is evidence that they include a sufficient number of strong juvenile year classes.

b. Populations will be considered to be “self-sustaining” if they have maintained stable or increasing population densities for at least twenty years. Higgins eye populations will be considered stable or increasing if: i. total mussel density in each of the identified Essential Habitat Areas is stable or increasing for at least twenty years (significance level (?) = 0.2 and power = 0.9); ii. and, in each of the identified Essential Habitat Areas, Higgins eye comprises at least 0.25% of the mussel community in the Mississippi River sites or, in other rivers, are consistently present throughout the twenty year period.

c. This criterion will be met if zebra mussels are not present in locations where they or their offspring are likely to adversely affect Higgins eye populations in any of the five identified Essential Habitat Areas. The Service will make this determination by evaluating zebra mussel densities in the source areas and identified Essential Habitat Areas, the distances between the zebra mussel populations and identified Essential Habitat Areas, water velocities, larval development times, and any other relevant information.

The above Intermediate Goal for Reclassification has not been met, as only the population in the Cordova Essential Habitat Areas meets the definition of reproducing and self-sustaining. Further, zebra mussels continue to threaten all of the existing populations. The zebra mussel portion of this criterion primarily addresses factor 5 (other natural or manmade factors affecting Higgins eye’s continued existence).

2. Complete the following tasks to determine if water quality criteria for the Final Goal (Delisting) are necessary to ensure the conservation of Higgins eye and, if so, to develop measurable water quality criteria for Goal 2. a. Develop a freshwater mussel toxicity database for sediment and water quality parameters to define Higgins eye habitat quality goals. b. Characterize specific sediment and water quality parameters in Higgins eye Essential Habitat Areas and reestablishment areas.

Intermediate Goal 2 for Reclassification has not been met, although general freshwater mussel toxicity tests are underway at the Columbia Environmental Research Center, including tests on other species of Lampsilis. Characterization of specific sediment and water quality parameters in Essential Habitat Areas has not been accomplished. This criterion addresses factor 1 (the present or threatened destruction, modification, or curtailment of its habitat or range).

3. Commercial harvest of freshwater mussels is prohibited by law or regulation in Essential Habitat Areas. This applies to all Essential Habitat Areas, not just the five identified for criterion 1.

Delisting Criteria:

1. Delisting Higgins eye requires that populations of Higgins eye in at least five Essential Habitat Areas are reproducing, self-sustaining, not threatened by zebra mussels, and are sufficiently secure to assure long-term viability of the species. The five Essential Habitat Areas must meet the above criteria and must include the Prairie du Chien Essential Habitat Area and at least one Essential Habitat Area each in the St. Croix River and in Mississippi River Pool 14. “Reproducing” and “self-sustaining” are defined above under the Intermediate Goal (Reclassification). Populations at the identified Essential Habitat Areas will be “sufficiently secure to assure the long-term viability of the species” if each of the following five conditions is met:

a. The Service can identify no activities that are likely to take place in the foreseeable future that will result in a change in the predominant substrate conditions within each identified Essential Habitat Area to shifting, unstable sands, silt, cobble, boulder, or artificial substrates (e.g., concrete) to the extent that such changes would appreciably reduce the likelihood of conserving the Higgins eye population in the Essential Habitat Area.

b. The Service can identify no activities that are likely to take place in the foreseeable future that will result in water quality characteristics (e.g., harmful concentrations of unionized ammonia) in Essential Habitat Areas that have been shown to cause detrimental effects to Higgins eye or to sympatric or surrogate species to the extent that such effects would appreciably reduce the likelihood of conserving the Higgins eye population in the Essential Habitat Area.

c. There is no indication that construction of barge loading or off-loading sites, boat harbors, highway bridges, or fleeting areas or dredging of access channels is likely to occur in the foreseeable future within the identified Essential Habitat Areas to the extent that such activities would appreciably reduce the likelihood of conserving the Higgins eye population in the Essential Habitat Area.

d. Measures that provide for review of federally funded, permitted, or planned activities in or near Higgins eye habitat pursuant to the Fish and Wildlife Coordination Act and Clean Water Act are in place.

e. This criterion will be met if zebra mussels are not present in locations where they or their offspring are likely to adversely affect Higgins eye populations in any of the five identified Essential Habitat Areas. The Service will make this determination by evaluating zebra mussel densities in the source areas and identified Essential Habitat Areas, the distances between the zebra mussel populations and identified Essential Habitat Areas, water velocities, larval development times, and any other relevant information.

2. The use of double hull barges or other actions have alleviated the threat of spills to each of the identified Essential Habitat Areas.

3. Higgins eye habitat information and protective responses to conserve each of the identified Essential Habitat Areas have been incorporated into all applicable spill contingency planning efforts.

4. Water quality criteria may be added to the criteria for the Final Goal (Delisting) upon completion of the tasks referred to under the Criteria for the Intermediate Goal (Reclassification).

Recovery Actions:

- 1. Identify, prioritize, and alleviate threats to Higgins eye in Essential Habitat Areas and prevent zebra mussel infestation of reintroduction areas. This action and the sub-actions described below address threats associated with Listing Factors A and E. 1.1. Assess and limit impact of the zebra mussel (Dreissena polymorpha) on Higgins eye. 1.1.1. Evaluate the feasibility of controlling zebra mussels in the Upper Mississippi River. 1.1.2. Develop strategies to prevent zebra mussel infestation for each EHA not yet infested and implement the strategies; 1.1.2.1. Develop a strategy to prevent zebra mussel infestation of the

Franconia EHA; 1.1.2.2. Develop a strategy to prevent zebra mussel infestation of the Orion EHA in the Wisconsin River; 1.1.2.3. Initiate actions to implement these strategies. 1.1.3. Develop strategies, as necessary, to prevent zebra mussel infestation for each reintroduction area where the risk of zebra mussel infestation is high. 1.1.3.1. Evaluate reintroduction areas to determine which areas, if any, are at high risk for zebra mussel invasion. 1.1.3.2. Work with state natural resource agencies and others, as necessary, to develop strategies to prevent zebra mussel infestation of any area at high risk for a significant infestation.

- 1.2. Incorporate Higgins eye habitat information into applicable spill contingency planning efforts; identify protective response actions available. 1.2.1. Coordinate with state and Federal natural resource trustees responsible for spill planning and response. Provide information on areas inhabited by Higgins 1.2.2. Identify potential response actions that may prevent or minimize impacts to Higgins eye and its habitat in the event of a spill of oil or hazardous materials. Incorporate into applicable response plans as necessary.
- 1.3. Ensure that all threats to Higgins eye in each EHA are identified and prioritized – initiate actions to remove or reduce the magnitude of any high priority threats; 1.3.1. Work with the recovery team to ensure that all current threats to Higgins eye in each EHA are identified and prioritized. 1.3.2. Set measurable objectives to alleviate each threat. For example, set measurable goals for fine sediment levels in the Franconia EHA on the St. Croix River. 1.3.3. Initiate actions to alleviate any high priority threats to each EHA.
- 2. Develop standard protocols for collecting and maintaining information on Higgins eye populations. This action and the sub-actions described below would ensure that the Service, its partners, and cooperating agencies possess the information necessary to efficiently and effectively address threats associated with Listing Factors A and E. 2.1. Evaluate current monitoring methods in cooperation with the Service's partners and in consultation with the recovery team to determine whether they are sufficient to: 2.1.1. Describe the presence and strength of Higgins eye juvenile year classes; 2.1.2. Estimate recruitment; 2.1.3. Determine whether Higgins eye populations are stable or growing; 2.1.4. Estimate population size. 2.2. Revise monitoring methods and/or recovery criteria, as appropriate;
- 3. Maintain a list and an ongoing evaluation of Essential Habitat Areas. This action and the sub-actions described below would ensure that the Service, its partners, and cooperating agencies possess the information necessary to efficiently and effectively address threats associated with Listing Factors A and E. 3.1. Maintain an accurate and up-to-date list of EHAs, including a summary of their status, on the Service's Region 3 website. 3.1.1. In cooperation with the recovery team, add areas to the list of EHAs that meet the criteria described in the recovery plan (U.S. Fish and Wildlife Service 2004:vi) and that are likely to support a reproducing and self-sustaining population of Higgins eye. 3.1.2. Revise the boundaries of EHA's, as appropriate. 3.1.2.1. In cooperation with the recovery team, revise the boundaries of the Cassville EHA to encompass the mussel bed described by Helms (2008). 3.1.2.2. Determine whether additional mussel surveys may be necessary to appropriately map the boundaries of the EHA at Mississippi River Mile 660 in Pool 9 and/or the Whiskey Rock EHA. One or more areas between these two EHAs appear to meet EHA criteria (Ecological Specialists 2008) and may warrant combining these two EHAs or revising their boundaries. 3.1.3. In cooperation with the recovery team, remove sites from the list of EHAs that no longer meet the recovery plan's criteria for EHAs (U.S. Fish and Wildlife Service 2004:vi) based on data collected over a minimum of ten years. Do not remove sites that contain (1) important components of the species' genetic diversity or (2) where zebra mussels are not present at harmful densities. 3.1.4. Maintain a list of "secondary" habitat

areas where additional surveys may be conducted, as funding permits, to determine if they warrant addition to the list of EHAs.

- 3.2. Estimate the existing genetic variability of the populations in Essential Habitat Areas. 3.2.1. Work with the recovery team to design a study that would describe the genetic diversity of Higgins eye populations in EHAs. 3.2.2. Implement the genetics study. The first step may require the development of microsatellite primers. The estimated cost for this step includes the resources needed to collect genetic samples from EHAs (# biodays) and the subsequent development of the primers ($). We assume that it will take a field crew of three biologists two days to collect – or attempt to collect – samples from 30 Higgins eye at each of the 14 EHAs.
- 3.3. Monitor mussel communities in at least four EHAs and in at least three reintroduction areas per year to determine: 3.3.1. The proportion of the native mussel community comprised of Higgins eye; 3.3.2. Density of native mussels; 3.3.3. The number of mussel species present at densities greater than 0.01/m2; 3.3.4. Effects of zebra mussels on native mussels.
- 4. Initiate actions to continue propagation and reintroduce Higgins eye into any historic habitats where reestablishment of reproducing and self-sustaining populations is feasible – focus on areas discrete from any areas in which the species may already have been successfully reintroduced and where zebra mussels are not an imminent threat. This action would help to reduce the magnitude of threats associated with Listing Factors A and E.

Conservation Measures and Best Management Practices:

- Conservation work has been an active area for Higgins eye since the last review in 2006. Major activities that have taken place include: monitoring, captive propagation and release, outreach, and funding acquisition. Monitoring: Monitoring of Higgins eye locations, including zebra mussel monitoring has occurred for several years at multiple locations (Appendix, Table 1). See EcoAnalysts, Inc. (2019), Smith (2019, 2020), and works cited within for more detailed survey and monitoring information. Captive Propagation and Release: Approximately 55,000 Higgins eye adults and subadults have been released into four rivers (Mississippi, Rock, Wisconsin, and Chippewa) and fish infested with millions of glochidia have been released into additional locations (Wisconsin, Iowa, Cedar, and Wapsipinicon) (Appendix, Table 2). It is too soon to determine whether these efforts have resulted in the successful reestablishment of the species in those areas. Releases in most locations occurred from 2000-2014, however recent releases continue in a few locations, including the Mississippi River at Hidden Falls (A. Scheunemann pers comm 2019) and the Chippewa River. In 2017, approximately 3,000 sub-adult Higgins eye were reintroduced to the Chippewa River near Meridean, WI (Smith 2018, p. 1) and 2,799 were released in 2018 at a nearby location (Smith and Bradley 2019, p. 9). Plans are in place to release Higgins eye at several additional locations on the Chippewa River to form a somewhat continuous population (USFWS 2018, entire). Outreach: Outreach has focused on informing the public about the decline of the freshwater mussels generally and increasing awareness and support for conservation activities, including captive propagation and releases. Funding: Partners have secured various sources of funds for Higgins eye conservation work, including but not limited to funds from the St. Louis, Rock Island, and St. Paul Districts of the Army Corps of Engineers, Legislative-Citizen Commission on Minnesota Resources (LCCMR), and State Wildlife Grants. (USFWS, 2020).
- Recommendations for future actions: Continue to preserve current populations of Higgins eye and their EHAs by doing the following actions: • Continue to quantify and limit the impact of zebra mussels. • Develop uniform protocols for collecting and maintaining information on Higgins eye populations and restoration projects (e.g., reintroductions). • Limit construction in areas of essential

Higgins eye habitat. Mitigation, including translocation, may be an acceptable alternative in limited instances. • Continue to examine the relationship between water quality, especially contaminants, and Higgins eye populations in EHAs. Develop water quality parameter goals for Higgins eye. Create an online, searchable, and curated mussel toxicity database. • Develop plans to reduce the shipment of toxic materials near Higgins eye habitat. • Incorporate EHAs and other important Higgins eye locations into spill response plans. • Review current regulations and develop additional regulation of mussel harvest in the upper Mississippi River drainage to reduce impacts on Higgins eye. • Develop materials to educate the public on the nature of endangered mussels and Higgins eye, in particular. • Require the use of double hull barges near EHAs or other important Higgins eye locations. Continue to enhance and restore populations of Higgins eye within its historical range including: • Identify and rank potential sites of existing Higgins eye populations for enhancement. • Increase the number of Higgins eye at enhancement sites to current levels found in EHAs or to numbers appropriate for the local habitat. • Continue to determine the feasibility of reestablishing Higgins eye into historical habitats, particularly streams that are at lower risk for zebra mussel colonization, and carry out reintroduction using the best available methods. • Examine the representation of Higgins eye using genetic techniques. Develop a genetics management plan, including a plan for long term genetic material storage. • Consider conducting a species status assessment (SSA) for the Higgins eye to determine appropriate measures of resiliency, representation, and redundancy to assess current and future conditions. Consider revisions to recovery plan per results of the SSA, if appropriate. (USFWS, 2020).

References

Revised recovery plan

nature serve. USFWS. 2020. Higgins Eye (Pearlymussel) (Lampsilis higginsii) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Minnesota – Wisconsin Field Office Bloomington, MN. 28 pp.

five year review, revised recovery plan. USFWS. 2020. Higgins Eye (Pearlymussel) (Lampsilis higginsii) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Minnesota – Wisconsin Field Office Bloomington, MN. 28 pp.

five year review, revised recovery plan

nature serve

five year review

spotlight action plan

USFWS. 2020. Higgins Eye (Pearlymussel) (Lampsilis higginsii) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Minnesota – Wisconsin Field Office Bloomington, MN. 28 pp.

SPECIES ACCOUNT: *Lampsilis perovalis* (Orangenacre mucket)

Species Taxonomic and Listing Information

Listing Status: Threatened; March 17, 1993; Southeast Region (R4) (USFWS 2000)

Physical Description

A medium-sized mussel, 50-90 mm (2-3.6 in) in length. The shell is oval in shape and moderately thick. The posterior margin of the shell of mature females is obliquely truncate (shortened). Nacre is usually rose colored, pink, or occasionally white. The periostracum ranges from yellow to dark reddish brown, with or without green rays (USFWS 2000).

Taxonomy

Lampsilis perovalis uses a structure known as a superconglutinate for larval dispersal. This structure was first discovered in 1988 (Hartfield and Butler, 1997) and may represent a previously undescribed genus among unionids (Paul D. Hartfield - pers. comm., 10/23/1995). Genetic analysis of L. perovalis is needed to determine if synonyms such as Lampsilis spillmani are genetically distinct from L. perovalis (James D. Williams, pers. comm. 10/10/1997). Lampsilis altilis, Lampsilis perovalis, Lampsilis subangulata, and Lampsilis australis have been placed into the new genus Hamiota (Roe and Hartfield, 2005) (NatureServe 2015).

Historical Range

Alabama River and tributaries, Alabama; tributary rivers and streams of the Tombigbee and Black Warrior Rivers, Mississippi and Alabama; Cahaba River and tributaries, Alabama (USFWS 2000).

Current Range

Buttahatchee River (Lowndes/Monroe County, Mississippi; Lamar County, Alabama), East Fork Tombigbee River (Itawamba, Monroe County, MS), Luxapalila Creek (Monroe County, Mississippi), Sipsey River (Greene/Pickens/Tuscaloosa County, AL), Coalfire, Lubbub, and Trussels Creeks (Pickens County, Alabama), North River (Tuscaloosa/Fayette County, Alabama) and its tributary Clear Creek (Fayete County, Alabama), Locust and Blackburn Forks of the Black Wan River (Blount County, Alabama), Sipsey Fork of the Black Warrior (Winston/Lawrence County, Alabama) and tributaries, Thompson, Flannagin, and Borden Creeks (Lawrence County, Alabama) and Caney, North Fork Caney, Brushy, Capsey, Rush, Brown, and Beech Creeks (Winston/Lawrence County, Alabama), Cahaba River (Bibb/Jefferson/Shelby County, Alabama), and Little Cahaba River (Bibb/Shelby County, Alabama) (USFWS 2000).

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin, as critical habitat for the orange-nacre mucket under the Endangered Species Act of 1973, as amended (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat is designated for the orange-nacre mucket (Lampsilis perovalis) in Units 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15; in AL and MS.

Unit 1. East Fork Tombigbee River, Monroe, Itawamba Counties, Mississippi. Unit 1 encompasses 26 km (16 mi) of the East Fork Tombigbee River channel in Mississippi extending from Mississippi Highway 278, Monroe County, upstream to the confluence of Mill Creek, Itawamba County, Mississippi. This reach of the East Fork Tombigbee River continues to support the southern clubshell and orange-nacre mucket (Hartfield and Jones, 1989; Miller and Hartfield, 1988; Mississippi Museum of Natural Science (MMNS) mussel collections, 1984–2001). This unit is within the historic range of the Alabama moccasinshell and ovate clubshell.

Unit 2. Bull Mountain Creek, Itawamba County, Mississippi. Unit 2 encompasses 34 km (21 mi) of the Bull Mountain Creek stream channel in Mississippi extending from Mississippi Highway 25, upstream to U.S. Highway 78, Itawamba County, Mississippi. Bull Mountain Creek supports the southern clubshell and Alabama moccasinshell (Jones and Majure, 1999). This unit is within the historic range of the orange-nacre mucket (records are from the early 1980's (MMNS mussel collections)) and the ovate clubshell.

Unit 3. Buttahatchee River and tributary, Lowndes/Monroe County, Mississippi; Lamar County, Alabama. Unit 3 encompasses 110 km (68 mi) of river and stream channel in Mississippi and Alabama, including 87 km (54 mi) of the Buttahatchee River, extending from its confluence with the impounded waters of Columbus Lake (Tombigbee River), Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and 23 km (14 mi) of Sipsey Creek, extending from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi. The Buttahatchee River continues to support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 2001; Hartfield and Jones, 1989; Jones, 1991; McGregor, 2000). The current distribution of the Alabama moccasinshell also extends into its tributary Sipsey Creek (McGregor, 2000).

Unit 4. Luxapalila Creek and tributary, Lowndes County, Mississippi; Lamar County, Alabama. Unit 4 encompasses 29 km (18 mi) of stream channel, including 15 km (9 mi) of Luxapalila Creek, extending from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and 15 km (9 mi) of Yellow Creek extending from its confluence with Luxapalila Creek, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama. Luxapalila and Yellow Creeks support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Hartfield and Bowker, 1992; McGregor, 2000; Miller, 2000; Yokley 2001).

Unit 5. Coalfire Creek, Pickens County, Alabama. Unit 5 encompasses 32 km (20 mi) of the Coalfire Creek stream channel extending from its confluence with the impounded waters of Aliceville Lake (Tombigbee River), upstream to U.S. Highway 82, Pickens County, Alabama. Coalfire Creek supports the orange-nacre mucket and ovate clubshell (P. Hartfield, Service field records 1991; McGregor, 2000). The creek is in the historic range of the southern clubshell and Alabama moccasinshell.

Unit 6. Lubbub Creek, Pickens County, Alabama. Unit 6 encompasses 31 km (19 mi) of the Lubbub Creek stream channel extending from its confluence with the impounded waters of Gainesville

Lake (Tombigbee River), upstream to the confluence of Little Lubbub Creek, Pickens County, Alabama. This stream supports the southern clubshell, orangenacre mucket, and Alabama moccasinshell (P. Hartfield, Service field records, 1991; McGregor, 2000; Pierson, 1991a). It is in the historic range of the ovate clubshell.

Unit 7. Sipsey River, Greene/Pickens, Tuscaloosa Counties, Alabama. Unit 7 encompasses 90 km (56 mi) of the Sipsey River channel from the confluence with the impounded waters of Gainesville Lake (Tombigbee River), Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama. This small river supports and provides some of the best remaining habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 1997; McCullagh et al., 2002; McGregor, 2000; MMNS Mussel Collection; Pierson, 1991 a, b).

Unit 8. Trussels Creek, Greene County, Alabama. Unit 8 encompasses 21 km (13 mi) of creek channel extending from its confluence with the impounded waters of Demopolis Lake (Tombigbee River), upstream to Alabama Highway 14, Greene County, Alabama. The orangenacre mucket continues to survive in Trussels Creek, and it is in the historic range of the ovate clubshell, Alabama moccasinshell, and southern clubshell (P. Hartfield field records, 1993; McGregor, 2000).

Unit 9. Sucarnoochee River, Sumter County, Alabama. Unit 9 encompasses 90 km (56 mi) of the Sucarnoochee River channel in Alabama, extending from its confluence with the Tombigbee River, upstream to the Mississippi/Alabama State Line, Sumter County, Alabama. The ovate clubshell continues to survive in the Sucarnoochee River (McGregor et al., 1996). The river is within the historic range of the southern clubshell, orangenacre mucket, and Alabama moccasinshell.

Unit 10. Sipsey Fork drainage, Winston, Lawrence Counties, Alabama. Unit 10 encompasses 147 km (91 mi) of stream channel in Alabama, including: Sipsey Fork, 31 km (19 mi), from section 11/12 line, T10S R8W, Winston County, upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, 8 km (5 mi), from confluence with Hubbard Creek, upstream to section 2 line, T8S R9W, Lawrence County, Alabama; Brushy Creek, 35 km (22 mi), from the confluence of Glover Creek, Winston County, Alabama, upstream to section 9, T8S R7W, Lawrence County, Alabama; Capsey Creek, 15 km (9 mi), from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County, Alabama; Rush Creek, 10 km (6 mi), from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County, Alabama; Brown Creek, 5 km (3 mi), from confluence with Rush Creek, Winston County, upstream to section 24 line, T8S R7W Lawrence County, Alabama; Beech Creek, 3 km (2 mi), from confluence with Brushy Creek, to confluence of East and West Forks, Winston County, Alabama; Caney Creek and North Fork Caney Creek, 13 km (8 mi), from confluence with Sipsey Fork, upstream to section 14 line, Winston County, Alabama; Borden Creek, 18 km (11 mi), from confluence with Sipsey Fork, Winston County, Alabama, upstream to the confluence of Montgomery Creek, Lawrence County, Alabama; Flannagin Creek, 10 km (6 mi), from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County, Alabama. The upper Sipsey Fork drainage currently supports the most robust and extensive populations of the dark pigtoe, orangenacre mucket, Alabama moccasinshell, and triangular kidneyshell (Haag and Warren, 1997; Haag et al., 1995; Hartfield, 1991; Hartfield and Butler, 1997; Hartfield and Hartfield, 1996; McGregor, 1992; Warren and Haag, 1994). Ovate clubshell have been reported from this drainage (Dodd et al., 1986).

Unit 11. North River and tributary, Tuscaloosa, Fayette Counties, Alabama. Unit 11 encompasses 47 km (29 mi) of river and stream channel in Alabama, including: North River, 42 km (26 mi) extending from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; Clear Creek, 5 km (3 mi), from its confluence with North River, to Bays Lake Dam, Fayette County, Alabama. Small numbers of the dark pigtoe and orange-nacre mucket continue to survive in the North River and Clear Creek (McGregor and Pierson, 1999; Pierson, 1992a; Vittor and Associates, 1993). This area is in the historic range of the Alabama moccasinshell, triangular kidneyshell, and ovate clubshell.

Unit 12. Locust Fork and tributary, Jefferson, Blount Counties, Alabama. Unit 12 encompasses 102 km (63 mi) of river and stream channel in Alabama, including: Locust Fork, 94 km (58 mi) extending from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; Little Warrior River, 8 km (5 mi), from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama. Scattered collections of the orange-nacre mucket and triangular kidneyshell suggest an enduring population of these species in the Locust Fork (P. Johnson pers. comm., 2002; Hartfield, 1991; Shepard et al., 1988). This stream is also in the historic range of the dark pigtoe, Alabama moccasinshell, ovate clubshell, and upland combshell.

Unit 13. Cahaba River and tributary, Jefferson, Shelby, Bibb Counties, Alabama. Unit 13 encompasses 124 km (77 mi) of river channel in Alabama, including: Cahaba River, 105 km (65 mi) extending from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; Little Cahaba River, 19 km (12 mi), from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama. Scattered individuals of triangular kidneyshell, orange-nacre mucket, and fine-lined pocketbook continue to be collected from the Cahaba drainage (R. Haddock, Cahaba River Society, pers. comm., 2002; McGregor et al., 2000; Shepard et al., 1994). The river is historic habitat for the Alabama moccasinshell, southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 14. Alabama River, Autauga, Lowndes, Dallas Counties, Alabama. Unit 14 encompasses 73 km (45 mi) of the Alabama River channel, extending from the confluence of the Cahaba River, Dallas County, upstream to the confluence of Big Swamp Creek, Lowndes County, Alabama. The southern clubshell is known to occur within this reach (Hartfield and Garner, 1998). This area may become suitable for reintroduction of the orange-nacre mucket.

Unit 15. Bogue Chitto Creek, Dallas County, Alabama. Unit 15 encompasses 52 km (32 mi) of the Bogue Chitto Creek channel in Alabama, extending from its confluence with the Alabama River, Dallas County, upstream to U.S. Highway 80, Dallas County, Alabama. This stream continues to support the southern clubshell and orange-nacre mucket (McGregor et al., 1996; P. Hartfield field notes, 1984; Pierson, 1991a). The habitat offers potential for the Alabama moccasinshell.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the orange-nacre mucket (Lampsilis perovalis) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: All mussels are filter feeders. Oxygen-bearing water and food are drawn into the incurrent siphon, and waste-carrying water is simultaneously passed out the excurrent siphon. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS 2000).

Reproduction Narrative

Adult: Sperm shed by the males are drawn into the marsupial water tubes by ciliary (pertaining to small hair-like processes) action, and the fertilized eggs begin developing into unique larval forms known as glochidia. Depending on the genus, all, or only a portion of the gills may carry the developing embryos. Glochidia measure only a fraction of a mm in size, and a single female may produce hundreds of thousands. All glochidia, with the possible exception of two species, appear to be obligate parasites of aquatic vertebrates. While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years. Discharge of superconglutinates by this species has been observed between March and June, with releases concentrated in early April. Redeye bass, spotted bass, and largemouth bass have been identified as host fish for the mucket. The duration of the parasitic period ranges from a week to several months, depending on species, temperature, and other factors (USFWS 2000).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2000)

Environmental Specificity

Adult: Unknown (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (USFWS 2000)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Currently restricted to high quality stream and small river habitat, the species is found on stable sand/gravel/cobble substrate in moderate to swift currents (USFWS 2000). This species is relatively tolerant of nondestructive intrusion, though heavy recreational use of habitat could potentially be excessively disruptive. Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). Separation barriers within standing water bodies are based solely on separation distance (see Separation Distance-suitable, below). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls. The environmental specificity is unknown (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low to moderate (inferred from NatureServe 2015 and USFWS 2000)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (USFWS 2000)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015). After the appropriate time, the glochidia metamorphose into juveniles, the cyst wall is ruptured and the juveniles drop to the bottom, often after having been transported for some distance by the host fish (USFWS 2000).

Population Information and Trends

Population Trends:

Declining (NatureServe 2015)

Number of Populations:

21 - 80 (NatureServe 2015)

Population Size:

Unknown (NatureServe 2015)

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

This species has a range extent of 400 - 2,000 square miles and an unknown population size. There are 21 - 80 occurrences, with 1 - 12 occurrences having good viability/integrity. Currently, this species is declining. Populations throughout most of range consist of a few, widely scattered individuals. Populations in streams in Bankhead National Forest may be stable. Populations have disappeared from the mainstem Tombigbee, Black Warrior, and Alabama Rivers (USFWS, 2004) (NatureServe 2015). No data on genetic variation or trends is available (USFWS 2008).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species. The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River

Basin. Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a mollusk-eating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Low numbers of this species in many stream drainages suggest marginal habitat conditions. All drainage populations remain susceptible to stochastic and chronic events (e.g., spills, drought and/or landuse runoff) (USFWS, 2008).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Stressor:
Exposure:
Response:

Consequence:
Narrative:

Recovery

Reclassification Criteria:
Reclassification does not appear to be a realistic goal for this species at this time (USFWS 2000).

Delisting Criteria:
1. At least eight (8) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (Factors A and E) (USFWS, 2019).

2. At least one (1) population (as defined in Criteria 1) occupies each of the presently occupied sub-basins (Alabama, Cahaba, Black Warrior, and Tombigbee) (as defined in Criterion 1) (Factors A and E) (USFWS, 2019).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A, D, and E) (USFWS, 2019).

Recovery Actions:
- Protect habitat integrity and quality (USFWS 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS 2000).
- The U.S. Forest Service has funded mussel surveys in streams under its jurisdiction, and has strengthened stream management zone guidelines on National Forest lands in Alabama. Other Federal and State agencies continue to conduct surveys of historically occupied habitat. A flood control projection Luxapalila Creek, Mississippi, was modified by the Corps of Engineers to protect listed mussel habitation that stream (USFWS 2000).
- Develop measurable recovery criteria for this species (USFWS 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS 2008).
- Develop and implement plan to describe and monitor habitat conditions where the mussels survive (USFWS 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan.

- Work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS 2000).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 29, 2016).

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 29, 2016)

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2019. Orangenacre mucket Amendment 1 to the U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Lampsilis powellii* (Arkansas fatmucket)

Species Taxonomic and Listing Information

Listing Status: Threatened; April 5, 1990, Southeast Region (R4) (USFWS 2013)

Physical Description

L. powellii is a medium sized freshwater mussel with a shiny olive brown to tawny colored shell. There are lines of tiny pits running down the shell that sometimes appear to be rays. The nacre is bluish-white and iridescent (NatureServe 2015).

Taxonomy

The Arkansas fatmucket was described as Unio powellii by Lea in 1852. It was synonymized under Actinonaias ligamenta by Call in 1895 (Harris and Gordon 1988). In 1900, Simpson placed it in the genus Lampsilis (Simpson 1914) (USFWS 1992).

Historical Range

The Arkansas fatmucket is endemic to the Ouachita Mountains region of Arkansas. Prior to the status assessment conducted by Harris and Gordon (1988), the known range of Arkansas fatmucket was restricted to 10 localities in the Ouachita River basin; one in the upper Ouachita River, two in the South Fork Ouachita River, two in the Caddo River, and five in the Saline River and forks (Gordon and Harris 1985). The historic range of this species likely included the Caddo River from Norman, Arkansas, to the confluence with the Ouachita River (approximately 64 river miles [rm]); South Fork Caddo River (approximately 4 rm); Ouachita River from the confluence of the Caddo River upstream to near Mena, Arkansas (approximately 160 rm); South Fork Ouachita River (approximately 29 rm); Alum Fork Saline River (approximately 53 rm); Middle Fork Saline River (approximately 30 rm); North Fork Saline River (approximately 22 rm); South Fork Saline River (approximately 15 rm); Saline River from its formation to U.S. Highway 270 (approximately 44 rm); and Hurricane Creek upstream of U.S. Highway 167 (approximately 18 rm) (USFWS 2013).

Current Range

The current known range is restricted to the Caddo River from the confluence of Collier Creek (between Norman and Caddo Gap, Arkansas) to Arkansas Highway 84 (near Amity, Arkansas; 24.3 rm); Ouachita River from near the confluence of Chances Creek to the confluence of Polk Creek (16.2 rm); Ouachita River from near the confluence of Snake Creek to Hole In The Ground Creek (7.8 rm); Ouachita River from Arkansas Highway 379 to U. S. Highway 270 (12.5 rm); Ouachita River from Interstate 30 to Arkansas Highway 222 (15 rm); South Fork Ouachita River from Montgomery County Road 17 to the inundation pool of Lake Ouachita (14.3 rm); Middle Fork Saline River from Arkansas Highway 7 to its confluence with the Alum Fork Saline River (30.2 rm); Alum Fork Saline River from Love Creek to the inundation pool of Lake Winona (5.6 rm); Alum Fork Saline River from Lake Winona Dam downstream to the Middle Fork Saline River confluence (28.0 rm); Alum Fork Saline River from the North Fork Saline River confluence upstream approximately 6.0 rm; North Fork Saline River from Arkansas Highway 9 to Arkansas Highway 5 (21.7 rm); Saline River from its formation downstream to U.S. Highway 270 (43.6 rm) (USFWS 2013).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Mussels are also dependent upon the water currents to bring food particles within the range of their siphons (USFWS 1992). The adults are detritivores while the immature form is parasitic (NatureServe 2015).

Reproduction Narrative

Adult: Scott (2004) and Christian et al. (2006) analyzed 137 Arkansas fatmucket specimens from the Saline and Ouachita River systems and found that sex ratio did not deviate significantly from the expected 1:1 ratio. The reproductive cycle of the Arkansas fatmucket is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gill marsupium until the larvae (glochidia) fully develop. The female releases her glochidia when a suitable fish host attacks the gill marsupium. The Arkansas fatmucket is gravid from March through October (Scott 2004). Scott (2004) and Christian et al. (2006) tested 26 fish species and one amphibian, the Red River mudpuppy (Necturus maculosus louisianensis) for their potential as suitable host. Glochidia successfully transformed on sunfishes (Centrarchidae), with greatest success occurring with the spotted bass (M. punctulatus) and largemouth bass (M. salmoides) (USFWS 2013).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2013)

Environmental Specificity

Adult: Moderate to broad (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Harris and Gordon (1988) identified four microhabitats for the Arkansas fatmucket: (1) pool segments between riffles with the substrate comprised primarily of cobble with sand and gravel interspersed and sufficient current to keep fine silt particles swept clean; (2) backwater areas downstream of islands or peninsulas covered with American water willow (Justicia americana); (3) pools upstream of water willow islands with depositional substrates consisting of sand, gravel, and cobble; and (4) overflow and secondary channels with permanent and backwater ponds located at the confluence of minor tributaries (USFWS 2013). The environmental specificity of this species is moderate to broad. Separation barriers within standing water bodies are based solely on separation distance (see Separation Distance-suitable, below). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low to moderate (inferred from NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: This species probably is rather sessile with only limited movement in the substrate. Passive downstream movement may occur when mussels are displaced from the substrate during floods. Major dispersal occurs while glochidia are encysted on their hosts (NatureServe 2015).

Population Information and Trends

Population Trends:

Declining (USFWS 2013)

Number of Populations:

6 - 20 (NatureServe 2015)

Population Size:

10,000 - 100,000 (NatureServe2015)

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

The species status is declining. Extant Arkansas fatmucket populations have been presumably extirpated from approximately 87 rm range-wide since listing, representing a 28 percent reduction in occupied stream reaches (USFWS 2013). The range extent of this species is 100 - 400 square miles, with an estimated population size of 10,000 - 100,000 individuals. There are 6 - 20 occurrences, with 4 - 12 occurrences having good viability/integrity.

Threats and Stressors

Stressor: Urbanization and changing land uses (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: A landscape level analysis of major land use changes within the watershed between 1986 and 2004 quantified changes in the watershed and determined anthropogenic impacts. The largest change (47 percent increase) in landscape classification was the increasing urbanization of the watershed characterized by the expansion of Benton and Hot Springs Village into rural areas. DeClerk et al (2006) ranked housing and urban development as the number one threat to the upper Saline River watershed. There was an increase in golf course coverage by 231 percent within Hot Springs Village. Unrestricted cattle access into streams, water withdrawal for agricultural and recreational purposes (i.e., golf courses), lack of adequate riparian buffers, construction and maintenance of county roads, and non-point source pollution arising from a broad array of activities, particularly rapid urbanization around Benton and Hot Springs Village, continue to increase and degrade suitable habitat for Arkansas fatmucket in the upper Saline River watershed (USFWS 2013).

Stressor: Timber production (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: Pine-dominated forest increased by 24 percent with a corresponding decrease in the natural mixed woods forest matrix by 22 percent. This change is indicative of increasing timber production activities (USFWS 2013).

Stressor: Gravel mining (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: Instream gravel mining in the South Fork Saline River is the primary source for the decline of Arkansas fatmucket and many other mussels. Instream gravel mining is also suspected as a cause of mussel declines in the Middle Fork Saline River. Instream gravel mining is also suspected of contributing to mussel declines in the Ouachita River and in headwater tributaries of the Caddo River, as well as the river proper. Gravel mining activities have resulted in numerous stream reaches with increased channel instability, increased sedimentation and altered instream habitat. The Service investigated a 2006 incident of illegal gravel mining in the Ouachita River at Cherry Hill. Over one hundred fresh dead mussels were collected in the spoils material (USFWS 2013).

Stressor: Erosion (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: Eroding stream banks are depositing sediment in downstream reaches resulting in a reduction of habitat quantity and quality. Urban development and farming practices that do not protect the vegetated stream corridors on private lands in and near Glenwood have led to unstable banks resulting in increased erosion and sedimentation in the Caddo River and its

tributaries (USFWS 2013).

Stressor: Impoundments (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: There are 19 impoundments located within the upper Saline River watershed. Nine new dams have been constructed in the Middle Fork Saline River watershed in conjunction with development of 15 Hot Springs Village (the largest gated community in the world). The expansion of water withdrawals, diversions, and impoundments is suspected to be one contributing factor to increases in elevated turbidity level during storm events, soil erosion/sediment instability and hydrologic alteration. Hydrologic alterations are a large contributing factor in geomorphic instability in the four forks of the Saline River. U.S. Geological Survey gaging stations on the Middle Fork Saline River exhibited an increasing trend in the annual number of zero-flow days (1986 – 2004), a trend consistent with increased consumptive water withdrawals within the tributary watersheds. One new dam was constructed on Big Cedar Creek, a tributary to South Fork Ouachita River. The Big Cedar Creek reservoir resulted in the first documented catastrophic decline of Arkansas fatmucket in the South Fork Ouachita River circa 1989 due to increased sedimentation during construction (USFWS 2013).

Stressor: Small isolated populations (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: The majority of the remaining Arkansas fatmucket populations are generally small and becoming more geographically isolated. The patchy distributional pattern of stream populations in short stream reaches makes them much more susceptible to extirpation due to the low potential for recolonization from other populations. Single catastrophic events, such as toxic chemical spills or other stochastic events, could cause the extirpation of any of these small, isolated Arkansas fatmucket occurrences. Increasing levels of isolation make natural repopulation of any extirpated population improbable without human intervention. Population isolation also prohibits the natural interchange of genetic material between populations. (USFWS 2013).

Stressor: Invasive species (USFWS 2013)
Exposure:
Response:
Consequence:
Narrative: Various invasive aquatic species (e.g., Asian clam (Corbicula fluminea)) are firmly established in the range of the Arkansas fatmucket. Increases in Asian clam populations have been noted by surveyors in recent years in degraded streams such as the Middle Fork Saline River. Arkansas Game and Fish Commission recently introduced a Tennessee strain smallmouth bass in the upper Ouachita River for recreational purposes. It is currently unknown whether Tennessee strain smallmouth bass are suitable host fish for Arkansas fatmucket. The replacement or diffusion of native Ouachita River smallmouth bass genetics with the Tennessee strain may reduce host availability for Arkansas fatmucket. However, the implications of stocking Tennessee strain smallmouth bass in the Ouachita River are unknown at this time (USFWS 2013).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. There are viable populations in the Ouachita River, South Fork Ouachita River, Alum, Middle, and North Forks Saline River, and main stem Saline River (USFWS 2013).

2. The habitat for these populations is fully protected (USFWS 2013).

3. Viable population levels are maintained for a period of at least 20 years (USFWS 2013).

Recovery Actions:
- Use legislation to protect habitat (USFWS 2013)
- Develop and implement a plan to protect habitat (USFWS 2013)
- Characterize habitat (USFWS 2013)
- Determine associate species (USFWS 2013)
- Develop life history data (USFWS 2013)
- Develop plan to restore historic habitat (USFWS 2013)
- Develop plan for reestablishing mussel populations (USFWS 2013)
- Implement plan to restore historic habitat (USFWS 2013)
- Develop plan for reestablishing mussel populations (USFWS 2013)
- Implement plan to restore historic habitat (USFWS 2013)
- Implement plan to reestablish population in historic habitat (USFWS 2013)
- Determine minimum population levels (USFWS 2013).
- Develop plan to monitor populations (USFWS 2013).
- Implement monitoring plan (USFWS 2013).
- The recovery plan should be revised to include downlisting and delisting criteria and better address the five factors (USFWS 2013).
- Finalize and implement the range-wide, programmatic Safe Harbor Agreement for Arkansas fatmucket (USFWS 2013).
- Determine age structure of extant Arkansas fatmucket populations (USFWS 2013).
- Implement high priority strategic actions outlined by DeClerk (2006) (USFWS 2013).
- Determine status of suitable host fish (e.g., how their distribution matches the distribution of Arkansas fatmucket?) (USFWS 2013).
- Determine habitat requirements of suitable host fish, condition/status of habitat (e.g., pristine, degraded), and restoration/protection needs (USFWS 2013).
- Actively use the U.S.D.A. Natural Resources Conservation Service's Farm Bill program and the Service's Partners for Fish and Wildlife Program to foster a working partnership with landowners, municipalities, industry, NGOs, and state and federal agencies to address and minimize threats (USFWS 2013).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Continue propagation and augmentation efforts in the Ouachita and Saline basins. 2. Implement the range wide programmatic Safe Harbor Agreement for Arkansas Fatmucket. 3. Implement high priority strategic actions outlined by DeClerk (2006). 4. Implement population health monitoring. 5. Collect age and growth data. 6. Conduct a thermal

tolerance study with Arkansas Fatmucket and its fish hosts that then models the possible effects of climate change over the last 50 years. 7. Determine status of fish hosts in relationship to Arkansas Fatmucket distribution. 8. Determine habitat requirements of fish hosts, condition/status of habitat (i.e., pristine, degraded, etc), and restoration/protection needs. 9. Conduct an analysis of historical sub-watershed and local buffer land use land cover, development, and impervious surface analyses, as well as a cumulative watershed sediment analyses. 10. Actively use the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program and U.S.D.A. Natural Resources Conservation Service's Farm Bill program to foster a working partnership with landowners, municipalities, industry, NGOs, and state and federal agencies to address and minimize threats. 11. Recent genetic analyses indicate the existence of two populations (Ouachita and Saline basins), each containing unique mtDNA haplotypes and microsatellite alleles. Protection of these two populations is important to maintain the unique genetic structure of the species. 12. Develop a population viability model. (USFWS, 2020)

References

USFWS 2013. Arkansas Fatmucket (Lampsilis powellii I. Lea, 1852) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Arkansas Ecological Services Field Office Conway, Arkansas

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 29, 2016)

U.S. Fish and Wildlife Service. 1992. Arkansas Fatmucket Mussel (Lampsilis powelli) Recovery Plan. U.S. Fish and Wildlife Service. Jackson, Mississippi. 19 pp.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 29, 2016)

USFWS 2013. Arkansas Fatmucket (Lampsilis powellii I. Lea, 1852) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Arkansas Ecological Services Field Office Conway, Arkansas.

USFWS. 2013. Arkansas Fatmucket (Lampsilis powellii I. Lea, 1852) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Arkansas Ecological Services Field Office Conway, Arkansas.

USFWS 2013. Arkansas Fatmucket (Lampsilis powellii I. Lea, 1852) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Arkansas Ecological Services Field Office, Conway, Arkansas.

USFWS. 2020. Arkansas Fatmucket (Lampsilis powellii) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Mississippi Basin Region Arkansas Ecological Services Field Office Conway, Arkansas . 40 pp.

SPECIES ACCOUNT: *Lampsilis rafinesqueana* (Neosho Mucket)

Species Taxonomic and Listing Information

Listing Status: Endangered; October 17, 2013; Southeast Region (R4)

Physical Description

The shell is up to 9.5 centimeters (cm) (4 inches), compressed, and relatively thin (Oesch 1984, pp. 219–221). The epidermis is olive-yellow to brown, becoming darker brown with age; green rays cover the surface, but are often discontinuous. The nacre (crystalline carbonate shell material of freshwater mussels) is bluish white to white (USFWS 2012).

Taxonomy

The Neosho mucket is a freshwater mussel in the family Unionidae. Neosho mucket was originally described as Lampsilis rafinesqueana from Indian Creek, McDonald County, Missouri (Frierson 1927, pp. 69–70). There is no synonomy (scientific names previously describing the same species) of the Neosho mucket (USFWS 2012).

Historical Range

The Neosho mucket is historically associated with the Illinois, Neosho, and Verdigris Rivers and their larger tributaries (Arkansas River basin) (USFWS 2015).

Current Range

The Neosho mucket is now limited to four drainage populations: the Neosho, Verdigris, Illinois, and Spring River drainages. In the Neosho River basin the species now survives in the Neosho River (KS), Elk River (MO), Spring River (MO, KS, possibly OK), North Fork Spring River (MO), Illinois River (OK, AR), and Shoal, Indian and Center creeks (MO). In the Verdigris basin the species survives in the Verdigris River (KS) and Fall River (KS) (USFWS, 2003) (NatureServe 2015).

Critical Habitat Designated

Yes; 4/30/2015.

Legal Description

On April 30, 2015, the U.S. Fish and Wildlife Service (Service), designated critical habitat for the Neosho mucket (Lampsilis rafinesqueana), under the Endangered Species Act of 1973, as amended (Act). In total, approximately 777 river kilometers (483 river miles) in Arkansas, Kansas, Missouri, and Oklahoma fall with the boundaries of the critical habitat designation for the Neosho mucket.

The Service finds the areas designated as critical habitat were occupied at the time of listing and contain the features essential to the conservation of the Neosho mucket.

Critical Habitat Designation

The critical habitat designation for Lampsilis rafinesqueana includes seven units totaling approximately 777 rkm (483 rmi) in Benton and Washington Counties, Arkansas; Allen, Cherokee, Coffey, Elk, Greenwood, Labette, Montgomery, Neosho, Wilson, and Woodson Counties, Kansas; Jasper, Lawrence, McDonald, and Newton Counties, Missouri; and Adair, Cherokee, and Delaware Counties, Oklahoma.

Unit NM1: Illinois River—Benton and Washington Counties, Arkansas; and Adair, Cherokee, and Delaware Counties, Oklahoma. Unit NM1 includes 146.1 rkm (90.8 rmi) of the Illinois River from the Muddy Fork Illinois River confluence with the Illinois River south of Savoy, Washington County, Arkansas, downstream to the Baron Creek confluence southeast of Tahlequah, Cherokee County, Oklahoma. This unit contains all or some components of all four physical or biological features and contains primary constituent elements 2, 3, 4, and 5. The physical or biological features in this unit may require special management considerations or protection to address changes in stream channel stability associated with urban development and clearing of riparian areas due to land use conversion in the watershed; alteration of water chemistry or water and sediment quality; and changes in stream bed material composition and quality from activities that would release sediments or nutrients into the water, such as urban development and associated construction projects, livestock grazing, confined animal operations, and timber harvesting. The majority of the riparian lands adjacent to, but not included in, this unit are in private ownership or private lands under tribal jurisdiction.

Unit NM2: Elk River—McDonald County, Missouri; and Delaware County, Oklahoma. Unit NM2 includes a total of 20.3 rkm (12.6 rmi) of the Elk River from Missouri Highway 59 at Noel, McDonald County, Missouri, to the confluence of Buffalo Creek immediately downstream of the Oklahoma and Missouri State line, Delaware County, Oklahoma. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The primary biological or physical features in this unit may require special management considerations or protection to address changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal; alteration of water chemistry or water quality; and changes in stream bed material composition and sediment quality from activities that would release sediments or nutrients into the water, such as urban development and associated construction projects, livestock grazing, confined animal operations (turkey and chicken), timber harvesting, and mining. All the riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit NM3: Shoal Creek—Cherokee County, Kansas; and Newton County, Missouri. Unit NM3 includes approximately 75.8 rkm (47.1 rmi) of Shoal Creek from Missouri Highway W near Ritchey, Newton County, Missouri, to Empire Lake where inundation begins in Cherokee County, Kansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes to the same activities as discussed in Unit NM2, above, and releases of chemical contaminants from industrial and municipal effluents (77 FR 63440, see Factor A). All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit NM4: Spring River—Jasper and Lawrence Counties, Missouri; and Cherokee County, Kansas. Unit NM4 includes 102.3 rkm (63.6 rmi) of the Spring River from Missouri Highway 97 north of Stotts City, Lawrence County, Missouri, downstream to the confluence of Turkey Creek north of Empire, Cherokee County, Kansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes to the same activities as discussed in Unit NM2, above, and releases of chemical contaminants from industrial and municipal effluents. Almost all (99 percent) of the riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit NM5: North Fork Spring River— Jasper County, Missouri. Unit NM5 includes 16.4 rkm (10.2 rmi) of the North Fork Spring River from the confluence of Buck Branch southwest of Jasper, Missouri, downstream to its confluence with the Spring River near Purcell, Jasper County, Missouri. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes to the same activities as discussed in Unit NM2, above. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit NM6: Fall River—Elk, Greenwood, and Wilson Counties, Kansas; Verdigris River—Montgomery and Wilson Counties, Kansas. Unit NM6 includes a total of 171.1 rkm (106.3 rmi), including 90.4 rkm (56.2 rmi) of the Fall River from Fall River Lake dam northwest of Fall River, Greenwood County, Kansas, downstream to its confluence with the Verdigris River near Neodesha, Wilson County, Kansas. Unit NM6 also includes 80.6 rkm (50.1 rmi) of the Verdigris River from Kansas Highway 39 near Benedict, Wilson County, Kansas downstream to the Elk River confluence near Independence, Montgomery County, Kansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes to the same activities as discussed in Unit NM2, above. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit NM7: Neosho River—Allen, Cherokee, Coffey, Labette, Neosho, and Woodson Counties, Kansas. Unit NM7 includes 244.5 rkm (151.9 rmi) of the Neosho River from Kansas Highway 58 west of LeRoy, Coffey County, Kansas, downstream to the Kansas and Oklahoma State line, Cherokee County, Kansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes to the same activities as discussed in Unit NM2, above, and releases of chemical contaminants from industrial and municipal effluents and tail water releases downstream of John Redmond Reservoir. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Neosho mucket consist of five components:

(i) Geomorphically stable river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with habitats that support a diversity of freshwater mussel and native fish (such as stable riffles, sometimes with runs, and mid-channel island habitats that provide flow refuges consisting of gravel and sand substrates with low to moderate amounts of fine sediment and attached filamentous algae).

(ii) A hydrologic flow regime (the severity, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for maintenance of the mussel's and fish host's habitat, food availability, spawning habitat for native fishes, and the ability for newly transformed juveniles to settle and become established in their habitats.

(iii) Water and sediment quality (including, but not limited to, conductivity, hardness, turbidity, temperature, pH, ammonia, heavy metals, and chemical constituents) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages.

(iv) The occurrence of natural fish assemblages, reflected by fish species richness, relative abundance, and community composition, for each inhabited river or creek that will serve as an indication of appropriate presence and abundance of fish hosts necessary for recruitment of the Neosho mucket. Suitable fish hosts for Neosho mucket glochidia include smallmouth bass (Micropterus dolomieu), largemouth bass (Micropterus salmoides), and spotted bass (Micropterus punctulatus).

(v) Competitive or predaceous invasive (nonnative) species in quantities low enough to have minimal effect on survival of freshwater mussels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as dams, piers and docks, bridges, or other similar structures) within the legal boundaries on June 1, 2015.

Special management considerations or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting each unit and to preserve and maintain the essential physical or biological features the critical habitat units provide to the Neosho mucket. Examples of special management actions that would minimize or ameliorate threats imposed by impoundments include: (a) Modified reservoir releases from dams to improve water quality and habitat conditions in many tailwaters, and (b) modified dam operations (for example, TVA's Tims Ford Dam on the Elk River, where water temperature is monitored and dam operation is adjusted to support endangered mussels downstream) and water quality and biological monitoring. Examples of special management actions that would minimize or ameliorate threats imposed by channelization include: (a) Determining distribution and abundance of mussels, (b) developing dredging protocols and mussel identification booklets to help minimize effects (for example, ACOE–Memphis District in the White River avoids dredging known mussel beds), and (c) funding research on geomorphological requirements of mussels to better inform management decisions. Examples of special management actions that would minimize or ameliorate threats imposed by sedimentation include: (a) Restoration and protection of riparian corridors, (b) implementation of best management practices to minimize erosion (such as State and industry practices for forestry activities), (c) stream bank restoration projects, and (d) private landowner programs to promote watershed and soil conservation. Examples of special management actions that would minimize or ameliorate threats imposed by chemical contaminants include: (a) Revising water quality standards (such as EPA's new ammonia aquatic life criteria), (b) implementing storm water best management practices, (c) promoting green areas along riparian corridors in rapidly developing urban areas (such as the Illinois River), (d) upgrading industrial and municipal treatment facilities to improve water quality in effluents, and (e) participating in private landowner programs to promote watershed conservation (such as USDA Farm Bill programs). Examples of special management actions that would minimize or ameliorate threats imposed by mining include: (a) Remediating soils contaminated with heavy metals (such as Tri-State Mining Area's reclamation of contaminated areas to improve water quality), and (b) partnering with industry to identify mussel locations to avoid during instream and alluvial sand and gravel mining operations. Examples of special management actions that would minimize or ameliorate threats imposed by oil and natural gas development include: (a) Developing and implementing best management practices for oil and natural gas development activities (such as Fayetteville Shale located in the upper Little Red River watershed), (b) partnering with industry and nongovernmental organizations to restore mussel habitat (such as Southwestern Energy's ECH20 (Energy Conserving Water) and the Archey Fork Little Red River Restoration Project), (c) creating conservation memoranda of agreement with industry to conserve mussel habitat (such as Crestwood Midstream in the upper Little Red River watershed), and (d) developing ecologically sustainable flow requirements for mussels. Examples of special management actions that would minimize or ameliorate threats imposed by invasive, nonindigenous species include: (a) Implementation of nonregulatory conservation measures to control Asian carp and other invasive, nonindigenous species, and (b) continued State engagement in efforts to minimize effects of Asian carp (such as eradication) on native fish resources. Examples of special management actions that would minimize or ameliorate threats imposed by temperature include: (a) Increase cold water temperature to optimal range for mussels by modification to tailwater releases, (b) improve industrial and municipal water treatment, and (c) protect and restore riparian habitat. Examples of special management actions that would minimize or ameliorate threats imposed by climate change include: (a) Reduce habitat fragmentation; (b) maintain ecosystem function and resiliency; (c) develop and implement strategies to help our native fish, wildlife, and habitats adapt to a changing climate; and (d) reduce nonclimate stressors.

Life History

Feeding Narrative

Adult: Mussels, such as the Neosho mucket, filter algae, detritus, microscopic animals, and bacteria from the water column (Fuller 1974, p. 221; Silverman et al. 1997, pp. 1862–1865; Nichols and Garling 2000, pp. 874–876; Strayer et al. 2004 pp. 430–431). Adult mussels also can obtain their food by deposit feeding, siphoning in food from the sediment and its interstitial (pore) water and pedal feeding directly from the sediment (Yeager et al. 1994, pp. 217–221; Vaughn and Hakenkamp 2001, pp. 1432–1438). Encysted (attached) glochidia are nourished by their fish hosts and feed for a period of one week to several months (USFWS 2015).

Reproduction Narrative

Adult: Neosho mucket spawns in late April and May, and female brooding occurs May through August. Barnhart (2003, p. 9) reported an average fecundity to be approximately 1.3 million glochidia per female in the Spring River, Kansas (USFWS 2012). Suitable fish hosts for Neosho mucket glochidia include smallmouth bass (Micropterus dolomieu), largemouth bass (Micropterus salmoides), and spotted bass (Micropterus punctulatus) (USFWS 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2015)

Environmental Specificity

Adult: Unknown (NatureServe 2015)

Site Fidelity

Adult: High (USFWS 2015)

Habitat Narrative

Adult: Little is known about habitat requirements of the Neosho Mucket. Neosho Mucket is associated with shallow riffles and runs comprised of gravel substrate and moderate to swift currents. The species is most often found in areas with swift current, but in Shoal Creek and the Illinois River it prefers near-shore areas or areas out of the main current. Threats to Neosho Mucket include curtailment of habitat and range, small population sizes, and their resulting vulnerability to natural or human induced events such as impoundments, sedimentation, chemical contaminants, mining, invasive species, and temperature. Mechanisms leading to the decline of Neosho Mucket range from local (e.g., riparian clearing, chemical contaminants, etc.) to regional influences (e.g., altered flow regimes, sedimentation, channelization, etc.), and global climate change. These factors may act in isolation, but it is probable that many stressors are acting simultaneously on Neosho Mucket populations (USFWS, 2018).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Number of Populations:

8 (USFWS, 2020)

Population Narrative:

Two Neosho Mucket populations persist within the Verdigris River basin, one population within the Illinois River basin, and five populations within the Neosho River basin, while its persistence in Cow Creek is unknown and Cottonwood River is questionable due to its recent (2015) reintroduction (Neosho River basin). Reservoir construction isolated each river basin and most populations within the river basin from each other. The Spring and North Fork Spring river populations are the only extant populations connected without barriers (e.g., dams) in the Neosho River basin, and the North Fork may be a meta-population depending upon results from ongoing genetics work. There also is connectivity between the two extant stream populations in the Verdigris River basin. Neosho Mucket individuals are widely scattered in isolated concentrations with low abundance within each population (river), except the Spring River where relatively high abundance still occurs at extant sites. (USFWS, 2020)

Threats and Stressors

Stressor: Impoundments (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: Dams eliminate and alter river flow within impounded areas, trap silt leading to increased sediment deposition, alter water quality, change hydrology and channel geomorphology, decrease habitat heterogeneity, affect normal flood patterns, and block upstream and downstream movement of mussels and fish (Layzer et al. 1993, pp. 68–69; Neves et al. 1997, pp. 63–64; Watters 2000, pp. 261–264). Within impounded waters, decline of mussels has been attributed to direct loss of supporting habitat, sedimentation, decreased dissolved oxygen, temperature levels, and alteration in resident fish populations (Neves et al. 1997, pp. 63– 64; Pringle et al. 2000, pp. 810–815; Watters 2000, pp. 261–264). Downstream of dams, mussel declines are associated with changes and fluctuation in flow regime, channel scouring and bank erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Williams et al. 1992, p. 7; Layzer et al. 1993, p. 69; Neves et al. 1997, pp. 63–64; Watters 2000, pp. 265–266; Pringle et al. 2000, pp. 810– 815) (USFWS 2015).

Stressor: Channelization (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: Dredging and channelization activities have profoundly altered riverine habitats nationwide. Hartfield (1993, pp. 131– 139), Neves et al. (1997, pp. 71–72), and Watters (2000, pp. 268–269) reviewed the specific upstream and downstream effects of channelization on freshwater mussels. Channelization affects a stream physically (accelerates erosion, increases sediment bed load, reduces water depth, decreases habitat diversity, creates geomorphic (natural channel dimensions) instability, and eliminates riparian canopy) and biologically (decreases fish and mussel diversity, changes species composition and abundance, decreases biomass, and reduces growth rates) (Hartfield 1993, pp. 131–139). Channel modification for navigation has been shown to increase flood heights (Belt 1975, p. 684), partly as a result of an increase in stream bed slope (Hubbard et al. 1993, p. 137) (USFWS 2015).

Stressor: Sedimentation (USFWS 2013)

Exposure:
Response:
Consequence:
Narrative: Excessive sediments are believed to negatively impact riverine mussel populations requiring clean, stable streams (Ellis 1936, pp. 39–40; Brim-Box and Mossa 1999, p. 99). Adverse effects resulting from sediments have been noted for many components of aquatic communities. Potential sediment sources within a watershed include virtually all activities that disturb the land surface. Specific biological effects include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, limited burrowing activity, physical smothering, and disrupted host fish attraction mechanisms (Ellis 1936, pp. 39–40; Marking and Bills 1979, p. 210; Vannote and Minshall 1982, pp. 4105–4106; Waters 1995, pp. 173–175; Hartfield and Hartfield 1996, p. 373) (USFWS 2013).

Stressor: Contaminants (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: Chemical contaminants are ubiquitous in the environment and are considered a major contributor to the decline of mussel species (Richter et al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007, p. 2029; Cope et al. 2008, p. 451). Chemicals enter the environment through point- and nonpoint-source discharges including spills, industrial and municipal effluents, and residential and agricultural runoff. These sources contribute organic compounds, heavy metals, nutrients, pesticides, and a wide variety of newly emerging contaminants such as pharmaceuticals to the aquatic environment (USFWS 2015).

Stressor: Mining (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: Gravel, coal, and metal mining are activities negatively affecting water quality in Neosho mucket habitat. Instream and alluvial gravel mining has been implicated in the destruction of mussel populations (Hartfield 1993, pp. 136–138; Brim-Box and Mossa 1999, pp. 103–104). Negative effects associated with gravel mining include stream channel modifications (altered habitat, disrupted flow patterns, sediment transport), water quality modifications (increased turbidity, reduced light penetration, increased temperature), macroinvertebrate population changes (elimination), and changes in fish populations, resulting from adverse effects to spawning and nursery habitat and food web disruptions (Kanehl and Lyons 1992, pp. 4–10). Anderson 1992 in Butler 2005, p. 102). Numerous mussel toxicants, such as polycyclic aromatic hydrocarbons and heavy metals (copper, manganese, and zinc) from coal mining, contaminate sediments when released into streams (Ahlstedt and Tuberville 1997, p. 75) (USFWS 2015).

Stressor: Oil and gas development (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: Exploration and extraction of these energy resources can result in increased siltation, a changed hydrograph (graph showing changes in the discharge of a river over a period of time), and altered water quantity and quality even at considerable distances from the mine or well field

because effects are carried downstream from the original source (USFWS 2015).

Stressor: Nonindigenous species (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: Invasive, nonindigenous species, such as zebra mussel, black carp, and Asian clam, have potentially adversely affected populations of the Neosho mucket and fish hosts, and these effects are expected to persist into the future (USFWS 2013).

Stressor: Temperature (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: Natural temperature regimes can be altered by impoundments, tailwater releases from dams, industrial and municipal effluents, and changes in riparian habitat. Low temperatures can significantly delay or prevent metamorphosis in mussels (Watters and O'Dee 1999, pp. 454–455). Cold water effluent below dams may negatively impact populations. Low water temperatures caused by dam releases also may disrupt seasonal patterns in reproduction (Galbraith and Vaughn 2009, pp. 43–44). High temperatures can reduce dissolved oxygen concentrations in the water, which slows growth, reduces glycogen stores, impairs respiration, and may inhibit reproduction (Fuller 1974, pp. 240–241). Water temperature increases have been documented to shorten the period of glochidial encystment, reduce righting speed (various reflexes that tend to bring the body into normal position in space and resist forces acting to displace it out of normal position), and slow burrowing and movement responses (Bartsch et al. 2000, p. 237; Watters et al. 2001, p. 546; Schwalb and Pusch 2007, pp. 264–265) (USFWS 2015).

Stressor: Climate change (USFWS 2015)
Exposure:
Response:
Consequence:
Narrative: As temperature increases due to climate change throughout the range of Neosho mucket, this species may experience population declines as warmer rivers become more suitable for thermally tolerant species. Overall, the distribution of fish species is expected to change, including range shifts and local extirpations (Ficke et al. 2005, pp. 67–69; 2007, pp. 603–605). Because freshwater mussels are entirely dependent upon a fish host for successful reproduction and dispersal, any changes in local fish populations would also affect freshwater mussel populations (USFWS 2015).

Recovery

Delisting Criteria:
(1) Two of four targeted river basins (Illinois, Verdigris, Neosho, and Spring River basins) contain viable populations 1 with positive or stable basin-wide population trend as evidenced by a population number measured with sufficient precision to detect change of ±25 percent (Factors A, D, and E). (2) Spatial distribution of natural or stocked aggregations distributed throughout the basin is sufficient to protect against local catastrophic or stochastic events (Factors A and E). (3) All life stages are supported by sufficient habitat quantity and quality (see Primary

Constituent Elements in Species Biological Report for Neosho Mucket) and appropriate presence and abundance of fish hosts necessary for recruitment (Factors A, D, and E). (4) Threats and causes of decline have been reduced or eliminated (Factors A, D, and E) (USFWS, 2018).

Recovery Actions:

- 1 . Establish viable populations within two of four targeted river basins (Illinois, Verdigris, Neosho, and Spring River basins) Illinois, Spring, Verdigris, and Neosho river basins (USFWS, 2018).
- 2. Develop and implement a monitoring protocol for the Neosho Mucket (USFWS, 2018).
- 3. Identify, prioritize and conduct research to enhance the conservation and recovery of Neosho Mucket (USFWS, 2018).
- 4. Watershed and habitat improvement and protection (USFWS, 2018)
- 5. Enhance the level of protection through policy, regulation, and enforcement (USFWS, 2018).
- 6. Develop and implement strategies to prevent the spread of competitive, nonindigenous (nonnative) species (USFWS, 2018).
- 7. Periodically review recovery progress and strategy (USFWS, 2018).
- A pilot propagation project was carried out in the Fall River, Kansas in the Fall River Wildlife Refuge where 19,550 laboratory reared juveniles were released (Barnhart and Baird, 2000). This propagation is showing some signs of success in Kansas streams (Anderson, 2006) (NatureServe 2015).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS We arranged the following recommendations for future conservation actions by general priority. 1. Complete ongoing Neosho Mucket genomics project. 2. Implement propagation, augmentation, and reintroduction efforts based on strategies developed from the Neosho Mucket genomics project. 3. Restore degraded Neosho Mucket habitat in the Tri-State Mining Area. 4. Implement watershed habitat improvement and protection of critical habitat. 5. Work with cities in rapidly growing urban areas in the Illinois and Spring River basins to adopt (codify) best management practices to protect water quality and minimize hydrologic alteration by promoting concepts that reduce impervious surfaces. 6. Conduct priority research identified in the Neosho Mucket Recovery Implementation Strategy. 7. Develop and implement a monitoring protocol for Neosho Mucket to assess its status rangewide at an appropriate interval or as necessary to accomplish management needs. (USFWS, 2020)

References

USFWS 2015. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Neosho Mucket and Rabbitsfoot

Final Rule. 80 Federal Register 83. April 30, 2015. Pages 24691 - 24774

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 29, 2016)

USFWS 2012. Endangered and Threatened Wildlife and Plants

Proposed Endangered Status for the Neosho Mucket, Threatened Status for the Rabbitsfoot, and Designation of Critical Habitat for Both Species

Proposed Rule. 77 Federal Register 200. October 16, 2012. Pages 63439 - 63536.

U.S. Fish and Wildlife Service. 2015. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Neosho Mucket and Rabbitsfoot. Final rule. 80 FR 24691 - 24774 (April 30, 2015).

Proposed Rule. 77 Federal Register 200. October 16, 2012. Pages 63439 - 63536. U.S. Fish and Wildlife Service. 2018. Final Recovery Plan for the Neosho Mucket (Lampsilis rafinesqueana). Southeast Regional Office, Atlanta, Georgia.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 29, 2016). USFWS. 2020. Neosho Mucket (Lampsilis rafinesqueana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Arkansas Ecological Services Field Office Conway, Arkansas. 49 pp.

USFWS. 2015. Endangered and Threatened Wildlife and Plants

Final Rule. 80 Federal Register 83. April 30, 2015. Pages 24691 - 24774.

U.S. Fish and Wildlife Service. 2018. Final Recovery Plan for the Neosho Mucket (Lampsilis rafinesqueana). Southeast Regional Office, Atlanta, Georgia.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 29, 2016).

USFWS. 2020. Neosho Mucket (Lampsilis rafinesqueana) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Arkansas Ecological Services Field Office Conway, Arkansas. 49 pp.

SPECIES ACCOUNT: *Lampsilis streckeri* (Speckled pocketbook)

Species Taxonomic and Listing Information

Listing Status: Endangered; February 28, 1989; Southeast Region (R4) (USFWS 2015)

Physical Description

The speckled pocketbook is a thin mussel in both shell thickness and depth of shell. It is about 80 millimeters (mm) (3.1 inches) long. The shells are elliptical, dark yellow or brown with chevron-like spots, and rays that are chain-like (Frierson 1927, Harris and Gordon 1990). The shells exhibit sexual dimorphism, with the females becoming broader and more evenly rounded posteriorly (USFWS 1991).

Taxonomy

Harries et al. (2004) investigated the limits and phylogeography of Lampsilinae in Arkansas with emphasis on species of Lampsilis. Speckled pocketbook specimens formed a well supported monophyletic group, within the Lampsilis reeveiana complex, that is significantly divergent from L. reeviana. This finding was consistent with the Speckled Pocketbook's current taxonomic status as a distinct species (USFWS 2015).

Historical Range

The speckled pocketbook is only known from the Middle Fork Little Red River, Van Buren and Stone Counties, Arkansas (USFWS 1991).

Current Range

The Speckled Pocketbook is currently restricted to the Middle Fork Little Red River from the influence of Greers Ferry Reservoir upstream to the confluence of Little Red Creek (63 river miles (rmi)), the South Fork Little Red River extending from 0.5 rmi downstream of Arkansas Highway 95 upstream to near the western boundary of Gulf Mountain Wildlife Management Area and the Ozark National Forest (15 rmi), Archey Fork Little Red River from approximately one rmi upstream of Arkansas Highway 65 to the confluence of Castleberry Creek (16 rmi), lower Turkey Creek (2 rmi), and Beech Fork (11 rmi) (USFWS 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Mussels dependent upon the water currents to bring food particles within the range of their siphons (USFWS 1991).

Reproduction Narrative

Adult: The reproductive cycle of the Speckled Pocketbook is similar to other native freshwater mussels. Males release sperm into the water column, which are taken in by females through their siphons during feeding and respiration. The female retain the fertilized eggs in their gill marsupium until the larvae (glochidia) fully develop. Gravid females have been observed from June - August in the Archey, Middle, and South Forks (Davidson and Wine 2004; Winterringer

2003; C. Davidson pers. comm.). Females have been observed releasing glochidia in February. Larvae successfully transformed on sunfishes (Centrarchidae), with greatest success occurring with the green sunfish (Lepomis cynaellus) (Winterringer 2003). Winterringer (2003) reported sex ratios from 1:1 - 1:1.5 male biased from collection sites in 2005 (USFWS 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2015)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Moderate to low (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Suitable habitat occurs in pools and runs with small to large boulders which have some accumulation of sand/gravel. Individuals are typically located in crevices between boulders or underneath perched boulders (Harris 1993; Winterringer 2003; C. Davidson pers. comm.) (USFWS 2015). The species is found in coarse to muddy sand in depths up to 0.4 meters (1.3 feet) with a constant flow of water. The occurrence in areas of constant water flow suggests a requirement for well-oxygenated conditions (USFWS 1991). The environmental specificity of this species is narrow, as it does not seem to be able to survive in slow current, pools, or stretches of river with intermittent flow. Separation barriers within standing water bodies are based solely on separation distance (see Separation Distance-suitable, below). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1991). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1991). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

Declining (USFWS, 2021)

Species Trends:

Declining (USFWS, 2021)

Number of Populations:

1 (NatureServe 2015)

Population Size:

˜ 300 (NatureServe 2015)

Population Narrative:

The status of this species is stable - the number of individuals at previously documented sites is equal to or greater than previous surveys (USFWS 2015). The only known population occupies less than 40 square miles with a population size of a few hundred (NatureServe 2015). Species Status: Declining. Based on long-term monitoring data obtained by the Service and AGFC staff, the Speckled Pocketbook population in Archey and Devil's Forks appear stable, albeit small. In the South and Middle Forks, number of individuals declined by 64 and 31 percent, respectively during the past decade. The Big Creek population is extremely small and 2019 surveys failed to detect the species. The Service and AGFC stocked 165 individuals at three Big Creek sites in 2021. Overall, Speckled Pocketbook appears to be declining. However, propagation efforts are proving successful and ongoing augmentation efforts may help reverse this trend until other conservation initiatives improve environmental conditions. (USFWS, 2021)

Threats and Stressors

Stressor: Alterations in stream temperature (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Alterations in stream temperature regimes associated with channel widening, riparian tree canopy removal, and climate change may affect Speckled Pocketbook biological processes

(USFWS, 2015).

Stressor: Habitat destruction and modification (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Existing threats include sediment and other contaminants derived from a variety of land use practices (i.e. Nonpoint source pollutants) and water consumption for fracking natural gas wells. Sediment and other chemical contaminants derived from gravel and rock mining, agricultural practices, and dirt and gravel road maintenance and construction appear to continue degrading suitable habitat (USFWS, 2015).

Stressor: Stochastic events (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Fragmentation and isolation of small populations, particularly in Big Creek and the Devils Fork complex, may play a magnified role in population extirpation associated with stochastic events (USFWS, 2015).

Recovery

Reclassification Criteria:
1. Four additional populations are discovered or reestablished (USFWS 2015).

2. All five populations are viable and the habitat fully protected (USFWS 2015).

3. Viable population levels are maintained for a period of at least 20 years (USFWS 2015).

Delisting Criteria:
1. Three (3) existing populations in the South Fork (1), Middle Fork (1), and Archey Fork (1) exhibit a stable or increasing trend, natural recruitment, and multiple age classes (Factors A, D, and E) (USFWS, 2019).

2. Individuals in populations (as defined in Criterion 1) are spatially distributed sufficient to protect against stochastic and catastrophic disturbance events (USFWS, 2019).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A, D, and E) (USFWS, 2019).

Recovery Actions:
- Protect the only known population and its habitat (USFWS 1991).
- Conduct life history research (USFWS 1991).
- Determine the feasibility of reestablishing the species (USFWS 1991).
- Develop and implement a plan to monitor all populations (USFWS 1991).
- Increase landowner enrollment in the programmatic SHA. Successful implementation of this agreement is essential to alleviating threats to water quality and habitat, thereby allowing for natural expansion of populations into uninhabited stream reaches and providing

protection for exiting extant populations (USFWS 2015).
- The recovery plan should be revised to refine reclassification criteria, define delisting criteria, and better address the five factors (USFWS 2015).
- Continue to collect data on size structure of extant Speckled Pocketbook populations (USFWS 2015).
- Determine importance of gene flow between different stream populations (USFWS 2015).
- Determine status of suitable host fish in the upper Little Red River watershed (e.g., how does their distribution match the distribution of Speckled Pocketbook?) (USFWS 2015).
- Determine habitat requirements of suitable host fish, condition/status of habitat (e.g., pristine, degraded, etc.), and restoration/protection needs (USFWS 2015).
- Continue to foster a working partnership with county governments, municipalities, industry, and private landowners to help minimize threats and promote recovery of Speckled Pocketbook (USFWS 2015).
- Monitor population status in the four forks of the Little Red River (USFWS 2015).
- Collect baseline information on distribution and abundance of Speckled Pocketbook in Big Creek (USFWS 2015).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS 1. Continue to implement future actions identified in the 2015 5-year review, except where otherwise specified below. 2. Remove #2 – the recovery plan was amended in 2019. 3. Number 4 is ongoing. Arkansas State University and Miami University will determine genetic variation within and among populations and determine effective population size. 4. Remove #9 – Big Creek was surveyed in 2019. 5. Determine sediment deposition rates vs. survivorship of Speckled Pocketbook (USFWS, 2021)

References

USFWS 2015. Speckled Pocketbook (Lampsilis streckeri Frierson 1927) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arkansas Ecological Services Field Office Southeast Region

U.S. Fish and Wildlife Service. 1991. Speckled Pocketbook Mussel (Lampsilis streckeri) Recovery Plan. U.S. Fish and Wildlife Service. Jackson, Mississippi. 14 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 30, 2016).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 30, 2016)

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 30, 2016). USFWS. 2021. Speckled Pocketbook (Lampsilis streckeri Frierson 1927) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arkansas Ecological Services Field Office Southeast Region. 42 pp.

USFWS. 2015. Speckled Pocketbook (Lampsilis streckeri Frierson 1927)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Arkansas Ecological Services Field Office, Southeast Region. 22 pp.

USFWS. 2019. Amendment to the Speckled Pocketbook (Lampsilis streckeri) Recovery Plan.

USFWS 2015. Speckled Pocketbook (Lampsilis streckeri Frierson 1927) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arkansas Ecological Services Field Office, Southeast Region.

USFWS. 2021. Speckled Pocketbook (Lampsilis streckeri Frierson 1927) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arkansas Ecological Services Field Office Southeast Region. 42 pp.

SPECIES ACCOUNT: *Lampsilis subangulata* (Shinyrayed pocketbook)

Species Taxonomic and Listing Information

Listing Status: Endangered; March 16, 1998; Southeast Region (R4) (USFWS 2007b)

Physical Description

This is a medium sized species with subelliptical shell, broad, somewhat inflated umbos and a rounded posterior ridge. Shell is fairly thin but solid. Surface is smooth and shiny, light yellowish brown in color with fairly wide, bright emerald green rays over the entire length of the shell. Older individuals may appear much darker brown with obscure raying. Females are more inflated postbasally, whereas males appear to be more pointed posteriorly. Nacre is white, with some individuals exhibiting a salmon tint in the umbonal cavity (Butler and Alam, 1999) (NatureServe 2015).

Taxonomy

The shinyrayed pocketbook was listed as federally endangered under the scientific name Lampsilis subangulata. The shinyrayed pocketbook and three other Lampsilis species are now assigned to the newly recognized genus Hamiota (Roe and Hartfield 2005, p. 1). (USFWS 2007a).

Historical Range

This species historically occurred in in the upper, middle, and lower Chattahoochee River (AL, GA); the upper, middle and lower Flint River (GA); the Apalachicola River (FL); Chipola River (FL); and the upper Ochocknee River (GA, FL) (USFWS 2007b).

Current Range

Extant populations occur in the middle and lower Chattahoochee River (AL, GA); the upper, middle and lower Flint River (GA); Chipola River (FL); and the upper Ochocknee River (GA, FL) (USFWS 2007b).

Critical Habitat Designated

Yes; 11/15/2007.

Legal Description

On November 15, 2007, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the endangered shinyrayed pocketbook (Lampsilis subangulata) under the Endangered Species Act of 1973, as amended (Act).

Critical Habitat Designation

Critical habitat is designated for the shinyrayed pocketbook (Lampsilis subangulata) in Units 2, 3, 4, 5, 6, 7, 9; in AL, FL, and GA.

Unit 2: Chipola River, Alabama and Florida. Unit 2 includes the main stem of the Chipola River (including the reach known as Dead Lake) and six of its tributaries, encompassing a total stream length of 190.0 km (118.1 mi) in Houston County, Alabama; and in Calhoun, Gulf, and Jackson counties, Florida. The main stem of the Chipola River as designated extends from its confluence with the Apalachicola River in Gulf County, Florida, upstream 144.9 km (90.0 mi) to the confluence of Marshall and Cowarts creeks in Jackson County, Florida. A short segment of the

Chipola River that flows underground within the boundaries of Florida Caverns State Park in Jackson County, Florida, is not included in Unit 2. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The tributaries of the Chipola River included in Unit 2 are: Dry Creek, from the Chipola River upstream 7.6 km (4.7 mi) to Ditch Branch in Jackson County, Florida; Rocky Creek, from the Chipola River upstream 7.1 km (4.4 mi) to Little Rocky Creek in Jackson County, Florida; Waddells Mill Creek, from the Chipola River upstream 3.7 km (2.3 mi) to Russ Mill Creek in Jackson County, Florida; Baker Creek, from Waddells Mill Creek upstream 5.3 km (3.3 mi) to the confluence with Tanner Springs in Jackson County, Florida; Marshall Creek, from the Chipola River upstream 13.7 km (8.5 mi) to the Alabama-Florida State line in Jackson County, Florida (this creek is known as Big Creek in Alabama); Big Creek, from the AlabamaFlorida State line upstream 13.0 river km (8.1 river mi) to Limestone Creek, in Houston County, Alabama; and Cowarts Creek from the Chipola River in Jackson County, Florida, upstream 33.5 river km (20.8 river mi) to the Edgar Smith Road bridge, in Houston County, Alabama. This unit is designated for the fat threeridge (Brim Box and Williams 2000, p. 92–93; Miller 1998, p. 54), shinyrayed pocketbook (Williams unpub. data 2002; Brim Box and Williams 2000, p. 109–110; Smith unpub. data 2001; Blalock-Herod unpub. data 2000, 2003; Butler unpub. data 1993, 1994, 1999, 2000); Gulf moccasinshell (Butler unpub. data 1999, 2002; Brim Box and Williams 2000, p. 113–114; D.N. Shelton pers. comm. 1998); oval pigtoe (Butler unpub. data 1993, 1999, 2002; Brim Box and Williams 2000, p. 116–117; Williams unpub. data 2000); and Chipola slabshell (Butler unpub. data 1993, 2000; Brim Box and Williams 2000, p. 95–96). PCEs in Unit 2 are vulnerable to impacts from sedimentation, urbanization, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 3: Uchee Creek, Alabama. Unit 3 encompasses 34.2 km (21.2 mi) of the main stem of Uchee Creek from its confluence with the Chattahoochee River upstream to Island Creek in Russell County, Alabama. This unit is designated for the shinyrayed pocketbook (Brim Box and Williams 2000, p. 109–110; Gangloff unpublished data 2005). PCEs in Unit 3 are vulnerable to impacts from sedimentation, urbanization, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 4: Sawhatchee Creek and Kirkland Creek, Georgia. Unit 4 includes the main stems of Sawhatchee Creek and Kirkland Creek and one tributary of Sawhatchee Creek, encompassing a total stream length of 37.8 km (23.5 mi) in Early County, GA. The main stem of Sawhatchee Creek as designated extends from its confluence with the Chattahoochee River upstream 28.6 km (17.8 mi) to the powerline crossing located 1.4 km (0.87 mi) upstream of County Road 15, Early County, GA. The main stem of Kirkland Creek extends from its confluence with the Chattahoochee River upstream 6.1 km (3.8 mi) to Dry Creek, Early County, GA. The tributary, Sheffield Mill Creek, is included from its confluence with Sawhatchee Creek upstream 3.1 km (1.9 mi) to the powerline crossing located 2.3 km (1.4 mi) upstream of Sowhatchee Road, Early County, GA. Unit 4 is designated for the shinyrayed pocketbook, Gulf moccasinshell, and oval pigtoe (Brim Box and Williams 2000, p. 109–110, 113–114, 116–117; Abbott pers. comm. 2005; Stringfellow pers. comm. 2003). PCEs in Unit 4 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 5: Upper Flint River, Georgia. Unit 5 includes the main stem of the Flint River and eight of its tributaries upstream of Lake Blackshear, plus two tributaries that flow into Lake Blackshear, encompassing a total stream length of 380.4 km (236.4 mi) in Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia. The main stem of the Flint River in designated Unit 5 extends from the State Highway 27 bridge (Vienna Road) in Dooly and Sumter counties, Georgia (the river is the county boundary), upstream 247.4 km (153.7 mi) to Horton Creek in Fayette and Spalding counties, Georgia (the river is the county boundary). The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributary streams in Unit 5 are: Swift Creek, from Lake Blackshear upstream 11.3 km (7 mi) to Rattlesnake Branch in Crisp and Worth counties, Georgia (the creek is the county boundary); Limestone Creek, from Lake Blackshear in Crisp County, Georgia, upstream 8.8 km (5.5 mi) to County Road 89 in Dooly County, Georgia; Turkey Creek, from the Flint River upstream 21.7 km (13.5 mi) to Rogers Branch in Dooly County, Georgia; Pennahatchee Creek, from Turkey Creek upstream 4.8 km (3 mi) to Little Pennahatchee Creek in Dooly County, Georgia; Little Pennahatchee Creek, from Pennahatchee Creek upstream 5.8 km (3.6 mi) to Rock Hill Creek in Dooly County, Georgia; Hogcrawl Creek, from the Flint River upstream 21.6 km (13.4 mi) to Little Creek in Dooly and Macon counties, Georgia (the creek is the county boundary); Red Oak Creek, from the Flint River upstream 21.7 km (13.5 mi) to Brittens Creek in Meriwether County, Georgia; Line Creek, from the Flint River upstream 15.8 km (9.8 mi) to Whitewater Creek in Coweta and Fayette counties, Georgia (the creek is the county boundary); and Whitewater Creek, from Line Creek upstream 21.5 km (13.4 mi) to Ginger Cake Creek in Fayette County, Georgia. Unit 5 is designated for the shinyrayed pocketbook (Dinkins pers. comm. 1999, 2003; P.D. Johnson pers. comm. 2003; Brim Box and Williams 2000, p. 109–110; Roe 2000; L. Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); Gulf moccasinshell (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002; Brim Box and Williams 2000, p. 113–114; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); oval pigtoe (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002, 2003; Stringfellow pers. comm. 2000, 2003; Abbott pers. comm. 2001; Brim Box and Williams 2000, p. 116–117; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997); and purple bankclimber (Winterringer CCR pers. comm. 2003; Dinkins pers. comm. 2003; P.D. Johnson pers. comm. 2003; Albanese pers. comm. 2003 regarding unpub. data from De Genachete and CCR; Brim Box and Williams 2000, p. 105–106; E. Van De Genachete pers. comm. 1999). PCEs in Unit 5 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’ Unit 5 is divided into two maps in the Regulation Promulgation section of this rule, one for the southern part and one for the northern part of the unit. The ‘‘match line’’ for joining these two maps is where the county boundary between Crawford and Upson counties, Georgia, meets the Flint River.

Unit 6: Middle Flint River, Georgia. Unit 6 includes the main stem of the Flint River between Lake Worth (impounded by the Flint River Dam near Albany) and the Warwick Dam (which impounds Lake Blackshear), and nine tributaries, encompassing a total stream length of 302.3 km (187.8 mi) in Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia. The main stem of the Flint River in Unit 6 extends from Piney Woods Creek in Dougherty County, Georgia (the approximate upstream extent of Lake Worth), upstream 39.9 km (24.8 mi) to the Warwick Dam in Lee and Worth counties, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Middle Flint River in Unit 6 are: Kinchafoonee Creek, from the LeeDougherty county line (the approximate upstream extent of Lake Worth) upstream 107.6 km (66.8 mi) to Dry Creek in Webster County, Georgia; Lanahassee Creek, from

Kinchafoonee Creek upstream 9.3 km (5.8 mi) to West Fork Lanahassee Creek in Webster County, Georgia; Muckalee Creek, from the Lee-Dougherty county line (the approximate upstream extent of Lake Worth) upstream 104.5 km (64.9 mi) to County Road 114 in Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km (4.5 mi) to Galey Creek in Schley County, Georgia; Mill Creek, from the Flint River upstream 3.2 km (2 mi) to Mercer Millpond Creek in Worth County, Georgia; Mercer Millpond Creek, from Mill Creek upstream 0.45 km (0.28 mi) to Mercer Millpond in Worth County, Georgia; Abrams Creek, from the Flint River upstream 15.9 km (9.9 mi) to County Road 123 in Worth County, Georgia; Jones Creek, from the Flint River upstream 3.8 km (2.4 mi) to County Road 123 in Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km (6.5 mi) to Dry Branch Creek in Lee County, Georgia. Unit 6 is designated for the shinyrayed pocketbook (Crow CCR pers. comm. 2004; Edwards Pittman Environmental 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; McCafferty pers. comm. 2000, 2001; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; BlalockHerod unpub. data 1997; Dinkins pers. comm. 1995; Brim Box and Williams 2000, p. 109–110), Gulf moccasinshell (Wisnewski unpub. data 2005; DeGarmo unpub. data 2002; Albanese pers. comm. 2003 regarding unpub. data from D. Shelton; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113– 114; Weston 1995), oval pigtoe (Wisnewski unpub. data 2005; Crow CCR pers. comm. 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; Stringfellow unpub. data 2002; Golladay unpub. data 2001, 2002; Brim Box and Williams 2000, p. 116–117; P. Johnson unpub. data 1999; Blalock-Herod unpub. data 1997; Weston 1995), and purple bankclimber (Tarbell 2004; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 6 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’ Unit 6 is divided into two maps in the Regulation Promulgation section of this rule, one for the western part and one for the eastern part of the unit. The ‘‘match line’’ for joining these two maps is Lake Worth in Dougherty County, Georgia.

Unit 7: Lower Flint River, Georgia. Unit 7 includes the main stem of the Flint River between Lake Seminole (impounded by the Jim Woodruff Lock and Dam) and the Flint River Dam (which impounds Lake Worth), and nine tributaries, encompassing a total stream length of 396.7 km (246.5 mi) in Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, GA. The main stem of the Flint River in Unit 7 extends from its confluence with Big Slough in Decatur County, GA (the approximate upstream extent of Lake Seminole) upstream 116.4 km (72.3 mi) to the Flint River Dam in Dougherty County, GA. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Lower Flint River in Unit 7 are: Spring Creek, from Smith Landing in Decatur County, Georgia (the approximate upstream extent of Lake Seminole), upstream 74.2 km (46.1 mi) to County Road 35 in Early County, Georgia; Aycocks Creek, from Spring Creek upstream 15.9 km (9.9 mi) to Cypress Creek in Miller County, Georgia; Dry Creek, from Spring Creek upstream 9.9 km (6.1 mi) to Wamble Creek in Early County, Georgia; Ichawaynochaway Creek, from the Flint River in Baker County, Georgia, upstream 68.6 km (42.6 mi) to Merrett Creek in Calhoun County, Georgia; Mill Creek, from Ichawaynochaway Creek upstream 7.4 km (4.6 mi) to County Road 163 in Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km (11.8 mi) to Little Pachitla Creek in Calhoun County, Georgia; Little Pachitla Creek, from Pachitla Creek upstream 5.8 km (3.6 mi) to Bear Branch in Calhoun County, Georgia; Chickasawhatchee Creek, from Ichawaynochaway Creek in Baker County, GA, upstream 64.5 km (40.1 mi) to U.S. Highway 82 in Terrell County, Georgia; and

Cooleewahee Creek, from the Flint River upstream 15.1 km (9.4 mi) to Piney Woods Branch in Baker County, Georgia. Unit 7 is designated for the shinyrayed pocketbook (Gangloff 2005; McCafferty pers. comm. 2004; Stringfellow unpub. data 2003; Dinkins pers. comm. 2001, 2003; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Albanese pers. comm. 2003 regarding unpub. data from CCR; Andrews pers. comm. 2000; BlalockHerod unpub. data 1997; Brim Box and Williams 2000, p. 109–110; Butler unpub. data 1993), Gulf moccasinshell (Abbott pers. comm. 2005; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113–114; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), oval pigtoe (Dinkins pers. comm. 2001; Golladay unpub. data 2001, 2002; Andrews pers. comm. 2000; Brim Box and Williams 2000, p. 116– 117; P. Johnson unpub. data 1999; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), and purple bankclimber (S. Carlson unpub. data 2002; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 7 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’ Unit 7 is divided into two maps in the Regulation Promulgation section of this rule, one for the western part and one for the eastern part of the unit. The western part (Map 10) depicts the Spring Creek system and the eastern part (Map 11) depicts the lower Flint River system.

Unit 9: Upper Ochlockonee River, Florida, Georgia. Unit 9 includes the main stem of the Ochlockonee River upstream of Lake Talquin (impounded by the Jackson Bluff Dam) and three tributaries, encompassing a total stream length of 177.3 km (110.2 mi) in Gadsden and Leon counties, Florida, and Grady and Thomas counties, Georgia. The main stem of the Ochlockonee River in Unit 9 extends from its confluence with Gulley Branch (the approximate upstream extent of Lake Talquin) in Gadsden and Leon counties, Florida (the river is the county boundary), upstream to Bee Line Road/County Road 306 in Thomas County, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The three tributary streams in Unit 9 are: Barnetts Creek, from the Ochlockonee River upstream 20 km (12.4 mi) to Grady County Road 170/Thomas County Road 74 in Grady and Thomas counties, Georgia (the creek is the county boundary); West Barnetts Creek, from Barnetts Creek upstream 10 km (6.2 mi) to GA Highway 111 in Grady County, Georgia; and Little Ochlockonee River, from the Ochlockonee River upstream 13.3 km (8.3 mi) to Roup Road/County Road 33 in Thomas County, Georgia. Unit 9 is designated for the shinyrayed pocketbook (Blalock-Herod 2003, p. 1; McCafferty pers. comm. 2003; Williams unpub. data 1993), Ochlockonee moccasinshell (Brim Box and Williams 2000, p. 60; Williams and Butler 1994, p. 64), oval pigtoe (Edwards Pittman Environmental 2004; Blalock-Herod unpub. data 2003; Blalock-Herod 2003, p. 1; Williams unpub. data 1993), and purple bankclimber (Blalock-Herod unpub. data 2003; Blalock-Herod 2002, p. 1; Smith FDOT unpub. data 2001; Williams unpub. data 1993). PCEs in Unit 9 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements of critical habitat for the shinyrayed pocketbook (Lampsilis subangulata) are:

(i) A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);

(ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay;

(iii) Permanently flowing water;

(iv) Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387); and

(v) Fish hosts (such as largemouth bass, sailfin shiner, brown darter) that support the larval life stages of the seven mussels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on the effective date of this rule and not containing one or more of the primary constituent elements.

Activities in or adjacent to each of the critical habitat units may affect one or more of the PCEs that are found in the unit. The features essential to the mussel species contained within the areas of the designation may require special management considerations or protections due to known or probable threats from these activities.

Management considerations to deal with sedimentation include protecting streams from sedimentation through application of agricultural and forestry best management practices, avoiding soiland vegetation-disturbing activity in the riparian zone, restoring unstable stream channels and other erosive areas, and other practices that prevent or reduce erosion.

Management considerations to deal with the threat of channel instability include avoiding soil- and vegetation-disturbing activity in the riparian zone, limiting impervious surface area, and other urban storm water runoff control methods. Sand and gravel mining (unit 3), dredging and channelization (unit 8), and dam construction (unit 5) may also affect channel stability.

Measures to deal with construction and operation of dams, water withdrawals, and water diversions include water conservation and operational strategies that manage water storage capacity and water demands in combination to minimize departures from the natural flow regime.

Management considerations to deal with the threat of pollution include applying agricultural and forestry best management practices, preserving native vegetation in riparian zones, maintaining septic systems, and taking other measures to minimize pollutantladen runoff to streams.

Life History

Feeding Narrative

Adult: Flowing water transports food items to the sedentary juvenile and adult life stages (USFWS 2007a). Presumably consumes fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species (NatureServe 2015).

Reproduction Narrative

Adult: The elaborate superconglutinate of the shiny-rayed pocketbook suggests it is a host-fish specialist that targets sight feeding piscivorous fishes, such as bass. O'Brien and Brim Box (1999, p. 136) confirmed that largemouth bass and spotted bass (Micropterus punctulatus) are likely primary hosts. Although female mussels may produce 75,000 to 3.5 million glochidia (Surber 1912, p. 3–10; Coker et al. 1921, p. 144; Yeager and Neves 1986, p. 333), contact of the glochidia with a suitable host fish is a low-probability event (Neves et al. 1997, p. 60) (USFWS 2007a). Gravid females found from December through August and superconglutinates released from late May to early July at water temperatures of 71.6 to 74.3F. It probably overwinters and releases in summer. Host fishes include Micropterus punctulatus (spotted bass), Gambusia holbrooki (eastern mosquitofish), Poecilia reticulata (guppy), Lepomis macrochirus (bluegill) (O'Brien and Brim Box, 1999) (NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe 2015)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (USFWS 2007a)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Adult unionid mussels are generally found in localized patches (beds) almost completely burrowed in the substrate with only the area around their siphons exposed (Balfour and Smock 1995, p. 255–268). Primary constituent elements for this species include a geomorphically stable stream channel; predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay; permanently flowing water; water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (USFWS 2007a). This is a medium creek to medium river species in clean or silty sand substrates in slow to moderate current with specimens often found in the interface of stream channel and sloping bank habitats (USFWS, 2003) (NatureServe 2015). The shinyrayed pocketbook was among the species with the highest mortality rates when exposed to DO concentrations less than 5 milligrams per liter (mg/L) (Johnson 2001) (USFWS 2007a). The environmental specificity of this species is narrow, as it is a clean-water species, and it is intolerant of stream impoundment. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS 2007a)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS 2007a)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (USFWS 2007a)

Dispersal/Migration Narrative

Adult: Adults and juveniles are relatively sedentary animals. They are unable to move quickly or across great distances from unsuitable to suitable microhabitats on and in the stream bed. Most unionid mussels depend on fish hosts for spatial dispersal (Neves 1993, p. 4) (USFWS 2007a). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

Improving (USFWS 2020)

Number of Populations:

36 (NatureServe 2015)

Population Size:

1,000 - 10, 000 (NatureServe 2015)

Population Narrative:

The status of this species is improving; recent surveys indicated range extensions (USFWS 2007b). The range extent of this species is 400 - 2,000 square miles, with an estimated population size of 1,000 - 10,000 individuals. There are currently 36 sites where this species occurs, with 1 - 12 occurrences having good viability/integrity (NatureServe 2015). The status of the shinyrayed pocketbook has improved due to finding additional populations since their listing in 1998 (USFWS 2007). Shinyrayed pocketbook however appears to be stable since 2007 as local populations that have declined has been offset with the discovery of additional populations. (USFWS, 2020)

Threats and Stressors

Stressor: Sedimentation (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: Sedimentation is an almost ubiquitous threat in the range this mussel. A wide variety of activities, such as livestock grazing, road and bridge construction, clear-cut logging, and off-road vehicle use, that are common in all 11 units may increase erosion rates, either in the banks of the stream channel itself or elsewhere in the watershed, and cause the accumulation of fine sediments on the stream bed (USFWS 2007a).

Stressor: Urbanization (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: Urbanization, road and bridge construction, and other large-scale alterations of land cover that substantially alter the runoff characteristics of the watershed may threaten channel stability in units near the major urban areas (USFWS 2007a).

Stressor: Altered hydrology (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: The construction and operation of dams, water withdrawals, and water diversions may alter features of the flow regime important to the mussels and their host fishes (USFWS 2007a).

Stressor: Pollution (USFWS 2007)
Exposure:
Response:
Consequence:
Narrative: Water pollution, especially from nonpoint (dispersed release) sources, is another almost ubiquitous threat. Water quality is reported as impaired or potentially impaired in some portions of the river basins within the current range of this species. Streams that receive a high proportion of their flow from the discharge of springs are vulnerable to nutrient enrichment from fertilizers and to other pollutants applied in the recharge areas of those springs, which may extend far from the streams themselves (USFWS 2007a).

Stressor: Insufficient host fish densities (USFWS 2007b)
Exposure:
Response:
Consequence:
Narrative: Riverine fish populations in the Southeast have been adversely affected by a variety of the same habitat alterations that have contributed to the decline of the region's mussel fauna (Etnier 1997; Neves et al. 1997; Warren et al. 1997) (USFWS 2007b).

Recovery

Reclassification Criteria:
1. The species has shown an increase in its current range to reflect occupation of at least 50 percent of its historic range (USFWS 2007b).

2. The species has at least three viable subpopulations in each of the watersheds that currently support the species (USFWS 2007b).

3. The species has at least ten viable subpopulations in the large river basins within the historic range of the species for at least 3 generations (USFWS 2007b).

Delisting Criteria:
Biennial monitoring shows an increase of the current number of subpopulation/sites and extent of occurrence is enough to ensure population viability, reduce isolation among populations, and increase the potential for genetic exchange. Specific increases needed are currently unknown (USFWS 2007b).

1. Populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes. 1a) At least eight (8) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (USFWS, 2019).

2. The spatial distribution of populations (as described in Criterion 1) are sufficient to protect against extinction from catastrophic events and maintain adaptive potential. Shinyrayed Pocketbook 2a) At least one (1) population in each of the Econfina Creek, Chipola, Chattahoochee, Flint, and Ochlockonee Rivers, and two (2) populations being located within the major tributary sub-basins of the Flint River (USFWS, 2019).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (USFWS, 2019).

Recovery Actions:
- 1. Preserve extant subpopulations and currently occupied habitats and ensure subpopulation viability (NatureServe 2015).
- 2. Search for additional subpopulations of the species and suitable habitat (NatureServe 2015).
- 3. Determine through research and propagation technology the feasibility of augmenting extant subpopulations and reintroducing the species into historical habitat (NatureServe 2015).
- 4. Evaluate efforts and monitor subpopulation levels and habitat conditions of existing subpopulations, as well as newly discovered, introduced, or expanding subpopulations (NatureServe 2015).
- 5. Develop and implement cryogenic techniques to preserve genetic material until such time as conditions are suitable for reintroduction (NatureServe 2015).
- 6. Develop and utilize a public outreach and environmental education program (NatureServe 2015).
- 7. Assess the overall success of the recovery program and recommend actions (e.g., changes in recovery objectives, delist, implement new measures, conduct additional studies) (NatureServe 2015).

- The subpopulation recovery criteria defining a subpopulation as a site is vague and less meaningful than actual density of population estimates. As the Service requires more information about population characteristics, the Service should revise recovery criteria. The Service recommends using quantitative methods to monitor changes in population size with each sub-basin (USFWS 2007b).
- Define "viable subpopulation" through implementation of Recovery Tasks 1.3.6, 1.3.7, and 1.3.8 (USFWS 2007b).
- Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders (USFWS 2007b).
- Continue to work with state and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies (USFWS 2007b).
- Work with the EPA and States to modify numerical water quality criteria for ammonia and copper (USFWS 2007b).
- Develop and implement a program to monitor subpopulation levels and habitat conditions of existing subpopulations (USFWS 2007b).
- Continue re-evaluating threats to these mussels (USFWS 2007b).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Define “viable population” through implementation of Recovery Tasks 1.3.6 and 1.3.7. 2. Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders. 3. Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies. 4. Assess the short and long-term effects of Hurricane Michael on the mussel populations in Spring and Econfina creeks. 5. Develop and implement a program to monitor population levels and habitat conditions of existing populations. 6. Identify and survey poorly explored suitable habitat in currently and historically occupied sub-basins where the species may be present in low numbers or where reintroduction may be feasible. (USFWS, 2020)

References

USFWS 2007a. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages

Final Rule. 72 Federal Register 220. November 15, 2007a. Pages 64286 - 64340

USFWS 2007b. Shinyrayed Pocketbook (Lampsilis subangulata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 30, 2016).

U.S. Fish and Wildlife Service. 2007. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Final rule. 72 FR 64286 - 64340 (November 15, 2007).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 30, 2016). U.S. Fish and Wildlife Service. 2019 Amendment 1 to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Gulf Moccasinshell (Medionidus penicillatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elliploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata). USFWS. 2020. Shinyrayed Pocketbook (Lampsilis subangulata (now known as Hamiota subangulata) Gulf Moccasinshell (Medionidus penicillatus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Office Athens, Georgia. 25 pp.

USFWS. 2007a. Endangered and Threatened Wildlife and Plants

Final Rule. 72 Federal Register 220. November 15, 2007. Pages 64286 - 64340.

Final Rule. 72 Federal Register 220. November 15, 2007a. Pages 64286 - 64340.

USFWS. 2007b. Shinyrayed Pocketbook (Lampsilis subangulata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 30, 2016).

U.S. Fish and Wildlife Service. 2019 Amendment 1 to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Gulf Moccasinshell (Medionidus penicillatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elliploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata).

USFWS. 2007b. Shinyrayed Pocketbook (Lampsilis subangulata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Panama City Field Office, Panama City, Florida.

USFWS. 2020. Shinyrayed Pocketbook (Lampsilis subangulata (now known as Hamiota subangulata) Gulf Moccasinshell (Medionidus penicillatus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Office Athens, Georgia. 25 pp.

SPECIES ACCOUNT: *Lampsilis virescens* (Alabama lampmussel)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 06/14/1976, 06/14/2001; Southeast Region (R4) (USFWS, 2016)

Physical Description

The Alabama lampmussel is a medium sized freshwater mussel usually measuring less than 75 millimeters in length with a moderately thick/moderately inflated shell that is often tawny to greenish yellow, with white nacre (Williams et al. 10 2008) (USFWS 2012).

Taxonomy

A member of the freshwater mussel family Unionidae, the Alabama lampmussel was originally described as Unio virescens (Lea, 1858). The type locality is the Tennessee River at Tuscumbia, Colbert County, Alabama (Figure 7) (Ortmann 1918, Parmalee and Bogan 1998). Parmalee and Bogan (1998) summarized the synonomy of the Alabama lampmussel; it has been considered a member of the genera Unio, Margaron, Lampsilis, and Ligumia at various times in history. It was first considered a member of the genus Lampsilis by Simpson in 1900 (Parmalee and Bogan 1998) (USFWS 2012).

Historical Range

The Alabama lampmussel historically occurred from the headwaters in eastern Tennessee downstream to Muscle Shoals in northwestern Alabama (Mirarchi 2004, Williams et al. 2008). It was known to occur in the PRR (Jackson Co., AL), Bear Creek (Colbert Co., AL), Little Bear Creek (Franklin Co., AL), a tributary to Bear Creek, Spring Creek (Colbert Co., AL), and Anderson Creek (Lauderdale Co., AL), a tributary to the Elk River (Ortmann 1918, Ortmann 1925, Isom and Yokley 1968, Isom and Yokley 1973) in northern Alabama, and the Emory River (Roane and Morgan counties, TN), and Coal Creek (Anderson Co., TN), a tributary to the Clinch River (Ortmann 1918, Ortmann 1925), in eastern Tennessee (USFWS 2012).

Current Range

It has been eliminated throughout a majority of its historic range, and is now restricted to only the upper reaches of the PRR system, Jackson County, Alabama, and potentially into Franklin County, Tennessee (Parmalee and Bogan 1998), and in the upper Emory River, Morgan County, Tennessee (Dinkens et al. 2012) (USFWS 2012).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Not available - presumed similar to other freshwater mussel species. Based on Lampsilis subangulata: Flowing water transports food items to the sedentary juvenile and adult life stages (USFWS 2007a). Presumably consumes fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species (NatureServe

2015).

Reproduction Narrative

Adult: This species is a long-term brooder and is gravid from late summer or autumn into the following summer (Williams et al. 2008). Work led by Dr. Paul Johnson at the Tennessee Aquarium Research Institute and staff at AABC has led to successful transformations of lampmussels on several different fish species in the family Centrarchidae, including rock bass (Ambloplites rupestris), green sunfish (Lepomis cyanellus), bluegill sunfish (L. macrochirus), smallmouth bass (Micropterus dolomieu), spotted bass (M. punctulatus), largemouth bass (M. salmoides), and redeye bass (M. coosae) (P. Johnson unpublished data, Fobian and Johnson 2010, Johnson and Hubbs 2010). The banded sculpin (Cottus carolinae) was also reported as a potential host (P. Johnson unpublished data) (USFWS 2012).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2012)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: It historically occurred in small creeks to large rivers; however, at present, it only seems to persist in small to moderate sized streams in areas of slow to moderate current within sand and gravel substrates. The lampmussel has also been found in areas with stands of water willow (Justicia americana) (Williams et al. 2008) (USFWS 2012). The environmental specificity of this species is narrow, as it is a small stream flowing water species. Separation barriers within standing water bodies are based solely on separation distance (see Separation Distance-suitable, below). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

Declining (NatureServe 2015)

Number of Populations:

1 - 5 (NatureServe 2015)

Population Size:

50 - 1,000 (NatureServe 2015)

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

The Alabama lampmussel is relatively uncommon, even among the best remaining populations, so genetic flow and diversity is a concern (USFWS 2012). The range extent is less than 40 square miles, with an estimated population size of 50 - 1,000 individuals. There are 1 - 5 occurrences, with none having good viability/integrity. The rate of decline for this species is undetermined, though extensive (NatureServe 2015). Natural populations are known to occur in the upper PRR and Emory River. However, these natural populations have a relatively low abundance. The species has been reintroduced into the lower PRR, Bear Creek, Estill Fork, Sequatchie River, Shoal Creek and Elk River. Surveys are needed to determine survival, reproductive success, and recruitment at reintroduced sites and identify if and when re-indtroduce populations are established and viable as defined in the recovery plan. (USFWS, 2020)

Threats and Stressors

Stressor: Channelization (USFWS 2012)
Exposure:

Response:
Consequence:
Narrative: One of the most damaging may be the channelization projects of the 1960s, which involved extensive stream channelization and removal of snags and riverbank timber in the mainstem PRR, Larkin Fork, Estill Fork, and Hurricane Creek (Barbour 2003) (USFWS 2012).

Stressor: Pollution (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Riffle and shoal habitats continue to be aggravated by non-point source pollution associated with agricultural runoff. Godwin (1995) noted single occurrences of the following potential impacts: sewage inflow, major logjam, siltation from construction, and drainage pipe (USFWS 2012).

Stressor: Gravel mining (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Lampmussel habitat has also been disturbed and degraded by unauthorized removal of creek gravel from within the stream channel at several locations within the PRR drainage basin (D. Fears pers. comm. 2011) (USFWs 2012).

Stressor: Stochastic events (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Natural factors such as drought can potentially threaten the continued existence of the Alabama lampmussel. Natural droughts can potentially have negative impacts on water quality (e.g., dissolved oxygen) and waste dissemination of point source discharges. Droughts may also reduce the amount of habitat available to mussels by dewatering habitat, and may also lead to direct mortality by stranding mussels. Drought may also fragment sections of stream into isolated pools, eliminating the required flow regime. Since the lampmussel's range is restricted to the PRR and Emory River drainages, human-induced random events such as toxic spills could also jeopardize the lampmussel if pollutants are spilled within creeks or rivers in either drainage. A kill associated with a major spill in the upper tributaries could potentially reduce the occupied range by at least half (USFWS 2012).

Stressor: Fish barriers (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Fish barriers, such as those caused by poorly designed road crossings, can limit fish movement, as well as distribution of freshwater mussels. In 2010, the Service assessed over 51 river mi (82 km) in the PRR basin and identified five high priority road crossings that likely function as fish barriers (B. Bouthillier, pers. comm. 2011). Three of these crossings were at locations known to support lampmussels, and therefore, are likely limiting lampmussel distribution by restricting movement of fish hosts. These barriers may also impact instream and

riparian habitat by altering flow direction and velocity, leading to scour holes and bank collapse (D. Fears pers. comm. 2011) (USFWS 2012).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. A viable population of Lampsilis virescens exists in the Paint Rock River above the impounded portion in Wheeler Reservoir, upstream to and including Larkin Fork, Estill Fork, and Hurricane Creek tributaries. This population should be distributed within this stream such that it is unlikely a single adverse event would result in the total loss of that population (USFWS 2012).

2. Through introductions and/or discoveries of new populations, a viable population is established in each of two additional streams within the historical range of this species. The population in each stream must be distributed such that a single adverse event would be unlikely to eliminate Lampsilis virescens from the river system. For these populations, surveys must show that three year classes exist including an adult year class naturally produced within each of the population centers and two younger year classes naturally produced within each of the population centers (USFWS 2012).

3. The species and its habitat in each stream are protected from foreseeable anthropogenic and natural threats (USFWs 2012).

Recovery Actions:
- Not available
- Continue working with local landowners to preserve the integrity of stream banks and riparian zone, and mitigate problem areas by utilizing cost-shares and other conservation initiatives (USFWS 2012).
- Conduct systematic population monitoring of extant and reintroduced populations including the documentation of potential threats (USFWS 2012).
- Specific life history and habitat needs have not been well documented; examine unknown components of life history and ecology, especially as it relates to host fish identification (USFWS 2012).
- Revise and update the recovery plan for the species to stress the importance of propagation/culture, enhancing our knowledge of basic biological processes (host fish identification, life history), and identify reintroduction as a primary recovery objective (USFWS 2012).
- Provide public outreach and education for the Alabama lampmussel, targeting property owners and farmers along the extant range (USFWS 2012).
- Continue to develop new partnerships and utilize conservation initiatives with landowners along the riparian habitats and within the recharge zone of the PRR drainage basin (USFWS 2012).
- Conduct genetic and histology research to support fitness of propagation and culture work (USFWS 2012).

- Conduct a detailed analysis of habitat requirements, including physiochemical parameters of the stream habitat used by the Alabama lampmussel (USFWS 2012).
- Encourage EPA and ADEM to develop water quality criteria for pollutants based on responses of native mollusk species, including the Alabama lampmussel (USFWS 2012).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS • Continue working with local landowners to preserve the integrity of stream banks and riparian zone, and mitigate problem areas by utilizing cost-shares and other conservation initiatives. • Conduct systematic population monitoring of extant natural and reintroduced populations including documentating local threats. • Specific life history and habitat needs have not been well documented; examine unknown components of life history and ecology • Continue propagation and culture activies. • Revise and update the recovery plan for the species to stress the importance of propagation/culture, enhancing our knowledge of basic biological processes (life history), and identify reintroduction as a primary recovery objective. • Develop a contingency plan to respond to a spill or natural disaster within occupied habitat. • Provide public outreach and education for the Alabama lampmussel, targeting property owners and farmers along the extant range. • Continue to develop new partnerships and utilize conservation initiatives with landowners along the riparian habitats and within the PRR and Emory River watershed. • Conduct genetic and histology research to inform propagation and culture work and ensure genetic fitness of reintroduced populations. • Conduct a detailed analysis of habitat requirements, including physiochemical parameters of the stream habitat used by the Alabama lampmussel. (USFWS, 2020)

References

USFWS 2012. Alabama Lampmussel (Lampsilis virescens) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama.

USFWS 2012. Alabama Lampmussel (Lampsilis virescens) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 31, 2016)

USFWS 2007a. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages

Final Rule. 72 Federal Register 220. November 15, 2007a. Pages 64286 - 64340.

USFWS 2012. Alabama Lampmussel (Lampsilis virescens) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama. USFWS. 2020. Alabama Lampmussel (Lampsilis virescens) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services

Field Office Daphne, Alabama. 37 pp.

USFWS. 2012. Alabama Lampmussel (Lampsilis virescens) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama.

USFWS 2012. Alabama Lampmussel (Lampsilis virescens) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office, Daphne, Alabama.

USFWS. 2020. Alabama Lampmussel (Lampsilis virescens) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 37 pp.

SPECIES ACCOUNT: *Lasmigona decorata* (Carolina heelsplitter)

Species Taxonomic and Listing Information

Listing Status: Endangered; June 30, 1993; Southeast Region (R4) (USFWS 2012)

Physical Description

The Carolina heelsplitter has an ovate, trapezoid-shaped, unsculptured shell. The shell of the largest known specimen of the species measures 114.8 millimeters (mm [4.6 inches]) in length, 39.0 mm (1.56 inches) in width, and 68.0 mm (2.7 inches) in height (Keferl 1991). The shell's outer surface varies from greenish brown to dark brown in color, and shells from younger specimens have faint greenish brown or black rays. The nacre (inside surface) is often pearly white to bluish white, grading to orange in the area of the umbo (Keferl 1991). However, in older specimens, the entire nacre may be a mottled pale orange (Keferl 1991) (USFWS 1996).

Taxonomy

The Carolina heelsplitter was originally described as Unio decoratus by Lea (1852). In 1970, this species was synonymized with Lasmigona subviridis (Conrad 1835) by Johnson (1970). Clarke (1985) recognized the Carolina heelsplitter as a distinct species, Lasinigona decorata, and synonymized Unio charlottensis (Lea 1863) and Unio insolidus (Lea 1872) with Lasinigona decorata (USFWS 1996).

Historical Range

Historically, the species was collected from the Catawba River, Mecklenburg County, NC; several streams and ponds in the Catawba River system around the Charlotte area of Meckienburg County, NC; one small stream in the Pee Dee River system in Cabarrus County, NC; one "pond" in the Pee Dee River system in Union County, NC; and an area in SC (covering portions of both the Saluda and Savannah River systems) referred to only as the Abbeville District, a terminology no longer employed (Clarke 1985, Keferl and Shelly 1988, Keferl 1991) (USFWS 1996).

Current Range

This species currently occurs in the Pee Dee River System: Goose Creek/Duck Creek (Union County, NC), Flat Creek /Lynches River (Lancaster, Kershaw, and Chesterfield Counties, SC); Catawba River System: Waxhaw Creek (Union County, NC and Lancaster County, SC), Sixmile Creek (Union and Mecklenburg Counties, NC, and Lancaster County, SC), Gills Creek/Cane Creek (Lancaster County, SC), Fishing Creek/South Fork Fishing Creek (Chester County, SC), Bull Run Creek/unnamed tributary to Bull Run Creek/Beaverdam Creek (Rocky Creek population) (Chester County, SC); Saluda River System: Red Bank Creek (Saluda County, SC), Halfway Swamp Creek (Greenwood and Saluda Counties, SC); Savannah River System: Turkey Creek/Mountain Creek/Beaverdam Creek/Sleepy Creek/Little Stevens Creek (Turkey Creek population) (Edgefield and McCormick Counties, SC), Cuffytown Creek (Greenwood and McCormick Counties, SC) (USFWS 2012).

Critical Habitat Designated

Yes; 7/2/2002.

Legal Description

On July 2, 2002, the Fish and Wildlife Service (Service) designated critical habitat for the Carolina heelsplitter (Lasmigona decorata), a freshwater mussel, pursuant to the Endangered Species Act of 1973, as amended (Act). The areas designated as critical habitat for the Carolina heelsplitter total approximately 148.4 kilometers (92.2 miles) of streams, including portions of three creeks in North Carolina and one river and six creeks in South Carolina. Section 7(a)(2) of the Act requires that each Federal agency shall, in consultation with the Service, insure that any action authorized, funded or carried out by such agency is not likely to jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse modification of critical habitat.

Critical Habitat Designation

Based on the most recent survey data for the Carolina heelsplitter (Keferl and Shelly 1988; Keferl 1991: Alderman 1995, 1998a, and 1998b; North Carolina Wildlife Resources Commission 1999 and 2000), there are currently six surviving populations: the Goose Creek/Duck Creek population, Waxhaw Creek population, Gills Creek population, Flat Creek/Lynches River population, Turkey Creek/Mountain Creek/Beaverdam Creek population, and Cuffytown Creek population. The areas in the six units that are designated as critical habitat for the Carolina heelsplitter include habitat for each of these populations. The lateral extent of designated critical habitat is up to the ordinary high-water line on each bank.

Unit 1. Goose Creek and Duck Creek (Pee Dee River system), Union County, NC. Unit 1 encompasses approximately 7.2 km (4.5 mi) of the main stem of Goose Creek, Union County, NC, from the N.C. Highway 218 Bridge, downstream to its confluence with the Rocky River, and approximately 8.8 km (5.5 mi) of the main stem of Duck Creek, Union County, NC, from the Mecklenburg/Union County line downstream to its confluence with Goose Creek. This unit is part of the currently occupied range of the Carolina heelsplitter and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area is occupied by one of the six known populations of the Carolina heelsplitter, and supports one of the only two known populations in the Pee Dee River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Carolina heelsplitter (Service 1997), protection of this unit is essential to the conservation of the species.

Unit 2. Waxhaw Creek (Catawba River system), Union County, NC. Unit 2 encompasses approximately 19.6 km (12.2 mi) of the main stem of Waxhaw Creek, Union County, NC, from the N.C. Highway 200 Bridge, downstream to the North Carolina/ South Carolina State line. This unit is part of the currently occupied range of the Carolina heelsplitter and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area is occupied by one of the six known populations of the Carolina heelsplitter, and supports one of the only two known populations in the Catawba River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Carolina heelsplitter (Service 1997), protection of this unit is essential to the conservation of the species.

Unit 3. Gills Creek (Catawba River system), Lancaster County, SC. Unit 3 encompasses approximately 9.6 km (6.0 mi) of the main stem of Gills Creek, Lancaster County, SC, from the County Route S–29–875, downstream to the S.C. Route 51 Bridge, east of the city of Lancaster. This unit is part of the currently occupied range of the Carolina heelsplitter and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area is occupied by one of the six known populations of the Carolina heelsplitter, and supports one of the only two known populations in the Catawba River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Carolina heelsplitter (Service 1997), protection of this unit is essential to the conservation of the species.

Unit 4. Flat Creek (Pee Dee River system), Lancaster County, SC, and the Lynches River (Pee Dee River system), Lancaster, Chesterfield, and Kershaw Counties, SC. Unit 4 encompasses approximately 18.4 km (11.4 mi) of the main stem of Flat Creek, Lancaster County, SC, from the S.C. Route 204 Bridge, downstream to its confluence with the Lynches River, and approximately 23.6 km (14.6 mi) of the main stem of the Lynches River, Lancaster and Chesterfield Counties, SC, from the confluence of Belk Branch, Lancaster County, northeast (upstream) of the U.S. Highway 601 Bridge, downstream to the S.C. Highway 903 Bridge in Kershaw County, SC. This unit is part of the currently occupied range of the Carolina heelsplitter and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area is occupied by one of the six known populations of the Carolina heelsplitter, and supports one of the only two known populations in the Pee Dee River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Carolina heelsplitter (Service 1997), protection of this unit is essential to the conservation of the species.

Unit 5. Mountain and Beaverdam Creeks (Savannah River system), Edgefield County, South Carolina, and Turkey Creek (Savannah River system), Edgefield and McCormick Counties, SC. Unit 5 encompasses approximately 11.2 km (7.0 mi) of the main stem of Mountain Creek, Edgefield County, SC, from the S.C. Route 36 Bridge, downstream to its confluence with Turkey Creek; approximately 10.8 km (6.7 mi) of Beaverdam Creek, Edgefield County, from the S.C. Route 51 Bridge, downstream to its confluence with Turkey Creek; and approximately 18.4 km (11.4 mi) of Turkey Creek, from the S.C. Route 36 Bridge, Edgefield County, downstream to the S.C. Route 68 Bridge, Edgefield and McCormick Counties, SC. This unit is part of the currently occupied range of the Carolina heelsplitter and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area is occupied by one of the six known populations of the Carolina heelsplitter, and supports one of the only two known populations in the Savannah River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Carolina heelsplitter (Service 1997), protection of this unit is essential to the conservation of the species.

Unit 6. Cuffytown Creek (Savannah River system), Greenwood and McCormick Counties, SC. Unit 6 encompasses approximately 20.8 km (12.9 mi) of the main stem of Cuffytown Creek, from the confluence of Horsepen Creek, northeast (upstream) of the S.C. Route 62 Bridge in Greenwood County, SC, downstream to the U.S. Highway 378 Bridge in McCormick County. This unit is part of the currently occupied range of the Carolina heelsplitter and, based on the best available information, provides the physical and biological habitat elements necessary for the life cycle needs of the species. The area is occupied by one of the six known populations of the Carolina heelsplitter, and supports one of the only two known populations in the Savannah River system. Based on our consideration of the best available information, including the recovery goals and criteria outlined in the recovery plan for the Carolina heelsplitter (Service 1997), protection of this unit is essential to the conservation of the species.

Primary Constituent Elements/Physical or Biological Features

Based on the best available information, the primary constituent elements essential for the conservation of the Carolina heelsplitter are:

(1) Permanent, flowing, cool, clean water;

(2) Geomorphically stable stream and river channels and banks;

(3) Pool, riffle, and run sequences within the channel;

(4) Stable substrates with no more than low amounts of fine sediment;

(5) Moderate stream gradient;

(6) Periodic natural flooding; and

(7) Fish hosts, with adequate living, foraging, and spawning areas for them.

Special Management Considerations or Protections

Critical habitat identifies specific areas that are essential to the conservation of a listed species and that may require special management considerations or protection.

Life History

Feeding Narrative

Adult: The Carolina heelsplitter feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (USFWS 1996).

Reproduction Narrative

Adult: The reproductive cycle of the Carolina heelsplitter is likely similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which are then parasitized for a short time while the glochidia develop into juvenile mussels (USFWS 1996). Fish species that successfully transformed glochidia to juveniles in the lab include: Bluehead chub (Nocomis leptocephalus) Highfin shiner (Notropis altipinnis) Creek chubsucker (Erimyzon oblongus) Spottail shiner (Notropis hudsonius) Bluegill (Lepomis macrochirus) Sandbar shiner (Notropis scepticus) Golden shiner (Notemigonus crysoleucas) Whitefin shiner (Cyprinella nivea) Rosyside dace (Clinostomus funduloides) Warmouth (Lepomis gulosus) Satinfin shiner (Cyprinella analostana) (USFWS 2012). Eads et al. (2010) found the species gravid from January and late February indicating it is bradytichtic, spawning in late summer or fall, and releasing glochidia in late winter or spring of the following year (NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Fragmented (USFWS 2012)

Environmental Specificity

Adult: Moderate (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low to moderate (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits cool, slow-moving, small- to medium-sized streams and rivers. The species' distribution is highly fragmented (USFWS 2012). It is usually found in mud, muddy sand, or muddy gravel substrates along stable, well-shaded stream banks (Keferl and Shelly 1988, Keferl 1991). The stability of stream banks appears to be very important to the species (Keferl 1991) (USFWS 1996). The environmental specificity of this species is moderate, as it is sensitive to water clarity and stream bank stability (USFWS, 1996) and substrates found in creek reaches associated with the species vary from clay to various combinations of coarse substrates. Separation barriers within standing water bodies are based solely on separation distance (see Separation Distance-suitable, below). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1996) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:
Declining (USFWS 2012)

Number of Populations:
11 (USFWS 2012)

Population Size:
1,000 - 2,500 (NatureServe 2015)

Adaptability:
Low (inferred from USFWS 2012)

Population Narrative:
The status of the species is declining. Although there are currently 11 known surviving populations of the Carolina heelsplitter, all of them are small to extremely small in size, and their genetic health and viability is, at best, highly questionable (USFWS 2012) The range extent of this species is 100 - 400 square miles with a population size of 1,000 - 2,500 individiuals. None of the known occurrences have good viability/integrity (NatureServe 2015).

Threats and Stressors

Stressor: Stochastic effects (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: All of the surviving populations are small to extremely small (see Table 1), highly fragmented, isolated from each other, and restricted to short stream reaches where they are vulnerable to extirpation from stochastic and chronic events (e.g., drought, toxic spills, land-use runoff, etc.). The genetic viability of the surviving populations remains a concern. All of the remaining populations of the Carolina heelsplitter appear to be effectively isolated from one another by impoundments, and several of these populations appear to be below the level required to maintain long-term genetic viability (USFWS 2012).

Stressor: Habitat alteration and degradation (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: All of the surviving populations continue to be threatened by many of the same factors identified at the time of listing, including habitat fragmentation, loss, and alteration

resulting from impoundments, the operation of hydroelectric dams, mining, wastewater discharges, and the runoff of silt and other pollutants from ground disturbance activities. Existing and potential future land uses within the watersheds of streams supporting the species threaten the habitat and water quality with increased discharge and runoff of silt, sediments, and organic and chemical pollutants. Past and on-going agriculture and timbering operations threaten several of the populations with continued loss of forest buffers; runoff of silt and other sediments; fertilizer, insecticide, and herbicide drift, runoff, and contamination of groundwater entering the streams; and destabilization of streambanks and substrate (from excessive stormwater runoff, loss of bank vegetation, livestock entering streams, etc.). Forestry activities on private land in the upper Turkey Creek watershed have been identified as a cause of habitat degradation in the headwaters of the Cuffytown, Mountain, Sleepy, and Little Stevens Creek subbasins (Alderman 2007). Long reaches of Fishing Creek, South Fishing Creek (Alderman 2007; Savidge, pers. comm., 2007), Rocky Creek, Bull Run Creek (Alderman 2007), Cane Creek, and Red Bank Creek (Savidge, pers. comm., 2006) have cut, eroding banks and carry heavy, unstable sediment loads from past and ongoing farming and forestry activities (USFWS 2012).

Stressor: Impoundments (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Numerous dams/impoundments exist on all of the major river systems within the range of the species (e.g., the Pee Dee, Catawba, Saluda, and Savannah River systems) and continue to fragment and isolate the surviving populations from one another. Additionally, some of these impoundments are now being used to supply water (several of which involve interbasin water transfers) to support the extensive development within and/or planned within the watersheds of several streams that support occurrences of the Carolina heelsplitter (USFWS 2012).

Stressor: Pollutants (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The loss of woodlands and forested stream buffers and the runoff 22 of pollutants and excessive stormwater from residential and commercial development activities, together with the effects of wastewater discharges from some of these developments, are contributing to a significant decline in the health and range of the Goose/Duck Creek population (pers. obs., 2003 through 2012). Extensive development has and is occurring throughout much of the Sixmile Creek watershed, and the upper Fishing Creek watershed is rapidly urbanizing. The effects of this development have likely contributed to a significant decline in these populations as well, and these effects pose a significant and increasing threat to the survival of the other populations of the species. Runoff from development activities in the upper Lynches River watershed, municipal wastewater discharge, and pollutants from past gold-mining activities continue to degrade and fragment aquatic habitat within this river (USFWS 2012).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, a total of four distinct viable populations1 exist. These four populations must be distributed throughout the species' known historic range, with at least one each in the Catawba, Pee Dee, and Savannah River systems. Also, these populations must be extensive enough that it is unlikely that a single event would eliminate or significantly reduce one or more of them (USFWS 2012).

Recovery Actions:
- Use existing legislation/regulations to protect the species (USFWS 1996).
- Elicit support for recovery efforts through the development and utilization of an information/education program (USFWS 1996).
- Search for new populations and monitor existing populations (USFWS 1996).
- Determine the species' life history, habitat requirements, and threats (USFWS 1996).
- Implement management and alleviate threats to the species' existence (USFWS 1996).
- Through augmentation, reintroduction, and protection, establish six viable populations (USFWS 1996).
- Develop and implement cryopreservation of the species (USFWS 1996).
- Improve planning, coordination, and efficacy of recovery activities with key partners (e.g., NCWRC, NCDWQ, NCNHP, Service, NRCS, local governments, local conservation NGOs, researchers, etc.) by meeting at least biennially to share information and review and recommend priority recovery actions (USFWS 2012).
- Continue working with state and local governments to implement protective regulations/ordinances for addressing the impacts and threats from development and other land-disturbance activities. One of the highest priorities is to continue pursuing the development of a conservation bank for the Carolina heelsplitter to provide for the protection of those populations of the species that, in terms of numbers, number of age classes present, range/amount of occupied habitat, availability of suitable habitat, land ownership, and existing land uses, represent the best remaining occurrences of the Carolina heelsplitter and offer the best opportunity for the long-term conservation and recovery of the species. Another priority is to continue working closely with state and local partners to develop, encourage public support for, and effectively implement protective water-quality management strategies for the Carolina heelsplitter, such as protective stream designations and site-specific plans like those required by North Carolina Procedures for Assignment of Water Quality Standards Rule 15A NCAC 02B.0110 (USFWS 2012).
- Formalize a detailed population and habitat monitoring plan for all surviving populations (USFWS 2012).
- Continue analyzing threats to the species and measures for offsetting these threats and to determine its specific vulnerability to commonly discharged wastes (e.g., ammonia, chlorine) for which present discharge limits may not be protective of mussels (USFWS 2012).
- Continue surveys for previously unknown occurrences of the species (USFWS 2012).
- Continue and expand captive propagation efforts. Several of the extant populations are likely to become extirpated in the very near future. These populations represent a significant portion of the species' historic geographic range. Without immediate efforts through captive holding and propagation to maintain the genetic material from these populations for augmentation and reintroduction efforts, we may forever lose the genetic

strains necessary for reestablishing these and other already extirpated populations of the species (USFWS 2012).

- Work in coordination with federal and state agencies, knowledgeable biologists, and land stewards, using information about current water quality, fish and mussel assemblages, current watershed conditions, and prospective protective mechanisms to identify and evaluate candidate streams for potential reintroduction efforts and reintroduce/establish new populations were feasible. Because of their small size, amount of habitat degradation that has already occurred, existing land uses, and degree of future threats, the conservation of some of the extant populations in the streams they currently occupy is likely untenable. Immediate efforts should be undertaken to secure individuals from these populations and move them to captivity for propagation or to refugia streams for reintroduction to suitable habitats. This would maintain the genetic diversity represented in these populations while allowing for development of wild, viable populations within the species' historic range (USFWS 2012).
- Determine intra- and interpopulation genetics. This information is necessary to estimate the relative viability of populations, provide guidance for augmentation and reintroduction efforts, and inform other potential management actions (USFWS 2012).
- Continue habitat, life-history, and captive-propagation studies aimed at specific conservation applications, including: (1) water temperature tolerances and optimal range; (2) in-stream flow requirements, dissolved oxygen requirements, and specific impacts from altered flow regimes; and (3) the continued support of controlled-propagation experiments USFWS 2012).
- Continue working with partners to establish conservation easements and restore forested buffers and in-stream habitat. Initially, these efforts should be focused primarily on the best of the remaining populations of the Carolina heelsplitter and areas targeted for reintroduction of the species (USFWS 2012).

References

USFWS 2012. Carolina Heelsplitter (Lasmigona decorata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina

U.S. Fish and Wildlife Service. 1996. Carolina Heelsplitter Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, GA. 30 pp.

U.S. Fish and Wildlife Service. 2002. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Carolina Heelsplitter. Final rule. 67 FR 44502 - 44522 (July 2, 2002).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 31, 2016)

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 31, 2016).

USFWS. 2012. Carolina Heelsplitter (Lasmigona decorata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina

U.S. Fish and Wildlife Service. 1996. Carolina Heelsplitter Recovery Plan. U.S. Fish and

USFWS 2012. Carolina Heelsplitter (Lasmigona decorata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office, Asheville, North Carolina

SPECIES ACCOUNT: *Lasmigona subviridis* (Green floater)

Species Taxonomic and Listing Information

Listing Status: Proposed Threatened

Physical Description

The green floater is a bivalve mollusk, similar to clams and oysters that has a hard shell made of calcium carbonate ($CaCO_3$) and a soft body. The shell is produced by tissue called the mantle, which is just inside the shell and encapsulates the internal organs. Green floaters are small; adults are generally less than 55 millimeters (mm) (2.2 inches [in]) in length (Johnson 1970, p. 344) though they can grow to 70 mm (2.8 in) (Watters et al. 2009, p. 347). The shell is yellowish brown to olive green with green rays and is thin and fragile with the umbo1 projecting slightly over the hinge (Bogan and Ashton 2016, p. 43) (Figure 2.1). The shell is ovate and trapezoidal in shape, compressed but inflated at the umbo (Clark 1981, p. 84) (Figure 2.3). The interior of the shell is creamy white in color (Figure 2.4). The foot color can range from white, to pale orange to orange (J. Jones and R. Mair pers. comm.; West Virginia Department of Natural Resources [WVDNR] 2008, p. 2). The larvae, called glochidia, are 0.36 mm (0.014 in) in length and 0.30 mm (0.011 in) in height and subtriangular, almost semicircular in shape with hooks (Johnson 1970, p. 345). Juveniles are spherical, have a tooth (hook) structure and measure 0.40 mm (0.016 in) in length (USFWS, 2021).

Taxonomy

The green floater, Lasmigona subviridis, was first described as Unio subviridis by Conrad in 1835, based on specimens from the Schuylkill River, Juniata River, and creeks in Lancaster County, PA (Conrad 1835, [Index, p. 4]). It was later placed in the genus Lasmigona (Platynaias) subviridis (Ortmann 1919, p. 121). Johnson (1970, p. 344) suggested that the Carolina heelsplitter (L. decorata = [Unio decoratus] (Lea 1852, p.19)) and L. subviridis were synonymous. Clarke (1985, pp. 51, 57-60) recognized the two species as distinct based on differences in size (length, volume and thickness) and color of the periostracum, which is the outermost layer of the shell. Clarke (1985, p. 60) also pointed out that L. decorata was observed in a pond, which was highly unusual for L. subviridis. The Service agreed that L. subviridis and L. decorata are distinct species when we listed the Carolina heelsplitter as an endangered species in 1993 (58 FR 34926) and designated critical habitat for the Carolina heelsplitter in 2002 (67 FR 44052). The currently accepted classification is (Integrated Taxonomic Information System 2019): Phylum: Mollusca Class: Bivalvia Order: Unionoida Family: Unionidae Subfamily: Unioninae Tribe: Anodontini Genus: Lasmigona Species: subviridis (USFWS, 2021)

Historical Range

he green floater is a small, greenish brown freshwater mussel historically native to the District of Columbia and 10 states including Alabama, Georgia, Maryland, New Jersey, New York, North Carolina, Pennsylvania, Tennessee, Virginia, and West Virginia. Green floaters are typically found in small streams to large rivers with slow to moderate flows (not high currents), in areas that provide flow refugia (i.e., eddies and ponded areas in streams), with stable sand and gravel substrate and good water quality. Connectivity between populations (free flowing streams and rivers without barriers) is necessary for periodic genetic exchange. Green floater populations are currently found in 8 of the 10 states (mentioned above) in their historical range and are considered extirpated in Alabama, Georgia, and the District of Columbia. They are also extirpated from multiple rivers across the rest of the range (USFWS, 2021).

Current Range

The current range (blue watersheds within figure 5.1) was determined based on the best available information using data from surveys conducted by partners, including state agencies, Federal agencies, nonprofit organizations and contractors. In some cases, surveys were conducted specifically for the green floater, while others targeted other mussel species (e.g., listed mussels) or were part of a general mussel survey. Data was provided as count data and presence/absence. If presence of live green floaters was noted between 1999 and 2019, it is considered recent (or extant) for the purposes of this SSA. The period between 1999 and 2019 was subjectively selected to represent recent occurrences. This period covers approximately 3 generations of green floaters which have a lifespan of between 3 and 7 years and is notable for the relative increase in survey effort which provides trend information over time at some locations. If green floater presence was recorded before 1999 and not afterwards, it is considered a past occurrence. Survey effort where the green floater has not been found since 1999 varies from not recently surveyed to periodically surveyed. This is reflected in the condition of analysis units, described later in the report (section 5.3). Live green floaters have been recently found (since 1999) in 7 of the 10 states in their known range. They are considered extirpated in Alabama and Georgia and there are no recent records from New Jersey or the District of Columbia. While green floaters have recently been found in New York, Pennsylvania, Maryland, West Virginia, Virginia, North Carolina and Tennessee, the range has contracted, and it now occurs as disjunct populations in rivers and streams in these states. For example, the green floater is considered extirpated from the Hudson (NY) and Mohawk (NY). It is also extirpated in individual tributaries to larger river systems such as the Delaware (NJ and PA), Susquehanna (PA), Potomac (WV), Kanawha (WV), Neuse (NC), and Tar River (NC) Basins. Green floaters have not recently been found in 48 percent (85 of 179) of the 10-digit HUCs where they have been documented. Few abundant populations remain and there has been a decline in numbers present at many locations. Despite increased survey effort for green floaters (especially in New York and Virginia), many of the recent occurrences are based on findings of less than 10 individuals found per analysis unit per year and often there was only one individual found (USFWS, 2021).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Dispersal/Migration

Population Information and Trends

Threats and Stressors

Stressor: Water Quality Degradation (USFWS, 2021)
Exposure:
Response:

Consequence:
Narrative: In addition to impacts to water quality from sedimentation (section 4.2), water quality can be degraded due to contamination or changes in temperature. Chemical contaminants are ubiquitous throughout the environment and are a major reason for the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Contaminants can enter streams and rivers through both point and nonpoint sources, including spills, industrial discharges, municipal effluents, agricultural runoff, and airborne deposition. These sources contribute excess nutrients, organic compounds, heavy metals, insecticides, herbicides, and a wide variety of newly emerging contaminants (e.g., antibiotics and hormones from wastewater treatment facilities) to the aquatic environment (USFWS, 2021).

Stressor: Excessive Sedimentation (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: Sedimentation originates from both instream (e.g., bank erosion, shifting channels) and upland sources (e.g., soil erosion). Increases in sediment load can accumulate on the stream/river bottom and may lead to bottom scour, embeddedness of rocks, gravel and cobble, and affect some baseline water quality parameters (e.g., turbidity). Impacts to mussels from excess sedimentation include abrasion of mussels by suspended particles, burial of mussels, increased mortality of host fish eggs and clogging of gills and respiratory systems in mussels and host fish (Wood and Armitage 1997, p. 211; Burkhead and Jelks 2001, p. 965). A reduced sediment load can also destabilize the stream channel. Additional adverse effects include alteration of physical habitat (e.g., change in amount and distribution of particle sizes often from activities like dredging, channelization or from natural events such as storms) and changes in primary productivity that can limit the suitability of stream habitats for the green floater and other aquatic species (Bogan 1993, p. 604; Wood and Armitage 1997, pp. 209-210; Taylor et al. 2007, p. 374). Mussels must have their valves open to feed; however, in heavily silted water, they are forced to close their valves and wait for better water conditions. Mussels in turbid water have been observed to close their valves up to 90 percent of the time, as opposed to 50 percent for individuals living in silt-free environments (Ellis 1936, p. 40). Extended valve closure can result in starvation or a state of semi-starvation. Extensive exposure to suspended sediments in the water column also affects individuals by clogging gill filaments, which significantly impacts feeding efficiency and filtering clearance rates which can result in mortality (Aldridge et al. 1987, p. 25; Brim Box and Mossa 1999, pp. 100-101). In addition to lethal impacts, increased TSS (total suspended solids) can reduce mussels' ability to become gravid (USFWS, 2021).

Stressor: Alteration of Water Flows (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: Mussels typically experience low flow and high flow periods and are adapted to deal with seasonal variability. However, extreme drought or flooding can adversely affect mussel populations that are already stressed (Hastie et al. 2001, p. 114; Golladay et al. 2004, p. 504). Low flow events (including stream drying) as well as high flow events can eliminate appropriate habitat for green floaters, and while the species can survive these events if the duration is short (in the case of stream drying), populations that experience these events regularly or for extended duration may be at risk. In addition, reductions in the diversity and abundance of mussels are

primarily attributed to habitat shifts caused by impoundments (Neves et al. 1997, p. 63). Impoundments and inundation of riffle habitat in central and eastern U.S. contributed to the extinction/extirpation of a number of North American freshwater mussels (Bogan 1993, p. 605). We discuss the potential effects of low/high water and impoundments such as dams and improperly constructed or maintained culverts have on mussels including the green floater (USFWS, 2021).

Stressor: Loss/Fragmentation of Suitable Habitat (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: Habitat fragmentation and population isolation contributes to the extinction risk that mussel populations face from stochastic events (Haag 2012, pp. 336-338). Streams are naturally dynamic, frequently creating, destroying, or shifting areas of quality habitat over a particular timeframe. Habitat fragmentation (natural and human-induced) in stream systems is brought about by a number of factors, most of which interact to create patches of suitable and unsuitable mussel habitat (USFWS, 2021).

Stressor: Climate Change (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: There are a multitude of ongoing and anticipated changes in the environment resulting from increased global temperatures and changes in precipitation. In this section, we highlight those that are related to the green floater. As mentioned in the Aquatic Ecosystems and Global Climate Change report (Poff et al. 2002, pp. ii-v), likely impacts of climate change on aquatic systems include: • Increases in water temperatures that may alter fundamental ecological processes, thermal suitability of aquatic habitats for resident species, as well as the geographic distribution of species. Adaptation by migration to suitable habitat might be possible; however, human alteration of dispersal corridors may limit the ability of species to relocate, thus increasing the likelihood of species extinction and loss of biodiversity. • Changes and shifts in seasonal patterns of precipitation and runoff will alter the hydrology of stream systems, affecting species composition and ecosystem productivity. • Aquatic organisms are sensitive to changes in frequency, duration, and timing of extreme precipitation events such as floods or droughts, potentially resulting in interference of reproduction. Further, increased water temperatures and seasonally reduced stream flows will alter many ecosystem processes. In addition, since sedentary freshwater mussels have limited refugia from disturbances such as droughts and floods, and since they are thermo-conformers whose physiological processes are constrained by water temperature within species-specific thermal preferences, climate-induced changes in water temperature can lead to shifts in mussel community structure (Galbraith et al. 2010, p. 1176). Extreme events (both floods and droughts) can also affect water quality parameters, including DO. Drought is a large-scale effect likely to operate at the local or regional level. Low water flows (e.g., following a prolonged summer drought) may expose mussels to intense opportunistic predation and this has been observed for a co-occurring species of floater, the brook floater, at several locations (USFWS, 2021)

Stressor: Invasive Species (USFWS, 2021)
Exposure:

Response:
Consequence:
Narrative: There is currently no information on the effect that invasive species may on green floater populations, however, when an invasive species is introduced to a natural system, it may have many advantages over native species, such as easy adaptation to varying environments and a high tolerance of living conditions that allows it to thrive in its nonnative range. There may not be natural predators to keep the invasive species in check; therefore, it can potentially live longer and reproduce more often, further reducing the biodiversity in the system. The native species may become an easy food source for invasive species, or the invasive species may carry diseases that could potentially wipe out populations of native species. Aquatic invasive species that are found in the range of the green floater include invasive freshwater mussels (Dreissena spp.), Asian clams (Corbicula fluminea), and invasive crayfish, notably the rusty crayfish (Faxonius rusticus), which is native to parts of Illinois, Kentucky, and Ohio, but invasive in the mid and south Atlantic part of its range (see section 4.7.2). Many nonnative fish species that may have changed the composition of the potential host community, some of which may eat mussels, may include smallmouth and largemouth bass, flathead and channel catfish, rock bass, common carp, and many others within the range of the green floater (USFWS, 2021).

Stressor: Predation (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: Approximately 18 percent of the watersheds known to have green floaters also are known to have rusty crayfish. The extent of impacts or degree of stress that rusty crayfish cause to the green floater are largely unknown. However, Klocker and Strayer (2004, entire) investigated potential impacts of the introduction of the rusty crayfish on native mussels by assessing their ability to eat various sizes of fingernail clams and another freshwater mussel, the Eastern elliptio. With a few exceptions, crayfish ate fingernail clams only if the clams were less than 7 mm (0.3 in) long and clams were less likely to be eaten if they were buried than if they were exposed (Klocker and Strayer 2004, p. 174). Crayfish ate 75 percent of the unionid mussels less than 8.9 mm (0.4 in) long, whether they were buried or exposed. No mussels greater than 8.9 mm (0.4 in) long were eaten, but 30 percent received extensive damage to the outer margin of their shells (Klocker and Strayer 2004, p. 174). The authors suggest that the introduction of the rusty crayfish poses a potential danger to native bivalve populations. However, a study conducted in southeastern New York found no association between recruitment failure of Elliptio complanata and crayfish (Strayer and Malcom 2012, p. 1783). Observations made during this study documented the presence of rusty crayfish at approximately 100 times greater than native crayfish at these sites. We expect that native and nonnative species prey upon mussels, however the extent of predation and its effect on green floater populations remain unknown throughout the range (USFWS, 2021).

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

-

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References

USFWS. 2021. Species Status Assessment Report for the Green Floater (Lasmigona subviridis). Version 1.1. New York Field Office, U.S. Fish and Wildlife Service, Cortland, New York. 111 pp + Appendices.

SPECIES ACCOUNT: *Lemiox rimosus* (Birdwing pearlymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 06/14/1976, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

It is a relatively small Cumberlandian species, seldom over 50 mm in length, 40 mm in height, and 25 mm in width (Stansberry, 1979). The surface of the shell is marked by strong, irregular growth lines, and the posterior half or two-thirds of the shell is marked by a string, corrugated, subradial sculpture (Bogan and Parmalee, 1983). The outer covering of the shell is generally olivaceous green or dark green to black (in older specimens), with faint rays often present in younger individuals. Inside coloration of the shell is always white and iridescent posteriorly (USFWS 1983).

Taxonomy

This species was described by Conrad in 1834 and is also referred to as Conradilla caelata (USFWS 1983).

Historical Range

Historically, the species occurred in the Tennessee River near the confluence of the French Broad and Holston Rivers, in the Holston River just upstream of its confluence with the French Broad River, and in the Nolichucky River (a French Broad River tributary) (Parmalee and Bogan 1998, p. 146). Archeological records (Parmalee 1988, p. 171) of this species exist from the Little Pigeon River, a lower French Broad River tributary (USFWS 2007).

Current Range

Across its range, it historically occurred in approximately 1,414 river miles, but the species is now restricted to approximately 171 river miles, a reduction of approximately 88%. It currently occurs in 40 miles of the Duck River, 103 miles of the Clinch River, and 28 miles of the Powell River. The population in the Duck and Clinch rivers appear to be stable, but the populations in the in the Powell River is declining. Since 1983, the range of the Birdwing Pearlymussel in the Powell River has declined 54%. (USFWS, 2020).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Water is siphoned for feeding (USFWS 1983).

Reproduction Narrative

Adult: The life history of this species is presumed similar to that of most unionids. Males produce sperm which are discharged into the surrounding water and dispersed by water currents. Females downstream obtain these sperm during the normal process of siphoning water during feeding and respiration (Stein, 1971). Fertilized eggs are retained in the gills, which are modified brood pouches. Ortmann (1916) collected gravid specimens in mid September, implying that it was a bradytictic species, which was confirmed by Charles Gooch in 1980 (pers. comm.) (USFWS 1983). The banded darter, (Etheostoma zonale) was identified as a potential host (Jenkinson, 1982; Hill, 1986). The snubnose darter (Etheostoma simoterum) was also identified as a suitable host by Schulz and Marbain (1998) and Watson and Neves (1998). Glochidia are contained only in the outer gills of females and are released in association with a mantle-lure display that appears to mimic a small aquatic snail (Jones et al., 2010). In the Clinch River, Tennessee, females are gravid October through May and likely August through July in the Duck River (Jones et al., 2010). Jones et al. (2010) determined the following to be suitable hosts: greenside darter (Etheostoma blennioides), bluebreast darter (Etheostoma camurum), redline darter (Etheostoma rufilineatum), snubnose darter (Etheostoma simoterum), banded darter (Etheostoma zonale) (NatureServe 2015). Some freshwater mussel species live up to 50 years or more (USFWS 1983).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe 2015)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: The environmental specificity of this species is narrow as it is a strict riffle dwelling species sensitive to changes in water quality and disturbance. This species is almost always found in riffle areas with stable, sand and gravel substrates in moderate to fast currents in small to medium sized rivers (Bogan and Parmalee, 1983; USFWS, 1983). Separation barriers within standing water bodies are based solely on separation distance. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

Stable (USFWS 2011)

Number of Populations:

1 - 5 (NatureServe 2015)

Population Size:

50 - 1,000 (NatureServe 2015)

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

The species status is stable based on the 2010 recovery data call. The birdwing pearlymussel population in the Duck River appears to be stable, while the populations in the Powell and Clinch River are declining (Nicholson 2006, pers. comm.). The status of historic birdwing pearlymussel populations in the Holston River and Elk River is unknown. No information is available concerning the genetics or genetic trends of this species (USFWS 2011). The range extent of this species is less than 40 square miles, with a population size of 50 - 1,000 individuals. There are 1 - 5 occurrences of this species, with 1 - 3 having good viability/integrity (NatureServe 2015).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 1984)
Exposure:
Response:
Consequence:

Narrative: The single greatest factor in the decline of the birdwing pearly mussel is the alteration and destruction of stream habitat due to impound of the Tennessee River and its tributaries for flood control, navigation, hydroelectric power production, and recreation. Stream impoundment affects species compositions by eliminating those species not capable of adapting to reduced flows and altered temperatures. Other factors affecting habitat are siltation (influenced by coal production) and various forms of pollutants, such as municipal, agricultural, and industrial waste discharges (USFWS, 1984).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:
There are no downlisting criteria for this species (USFWS 2011)

Delisting Criteria:
1. A viable population of birdwings exists in the Clinch River from the backwaters of Norris Reservoir upstream to approximately CRM 280 and in the Powell River from the backwaters of Norris Reservoir upstream to approximately PRM 130. These two populations are dispersed throughout each river, so that it is unlikely that any one event would cause the total loss of either population (USFWS 2011).

2. Through reestablishments and/or discoveries of new populations, viable populations exist in three additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate birdwings from the river system. (If the Duck River Columbia Dam project is not completed and a viable population of the species continues to exist in the Duck River, only two additional populations will be needed to meet this criterion.) (USFWS 2011).

3. The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (USFWS 2011).

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal-related siltation has occurred in the Clinch River (USFWS 2011).

Recovery Actions:
- Develop propagation technology for the cracking pearlymussel and birdwing pearlymussel. Continue propagation of the dromedary pearlymussel for augmentation of extant populations and reestablishment of new populations (USFWS 2011).
- Augment existing populations to ensure viability (USFWS 2011).
- Reestablish populations into suitable habitat in other streams within the species' historic ranges (USFWS 2011).

- Work with other Federal agencies, State agencies, individuals, and other partners to restore, maintain, and protect suitable habitat in the rivers containing extant and reestablished populations of these species (USFWS 2011).
- Continue to explore the feasibility of cryogenic preservation of gametes and/or larvae of the birdwing pearlymussel, dromedary pearlymussel, and cracking pearlymussel. Advances in cryopreservation technology since previous efforts with mussels may now make this technique of protecting genetic material feasible (USFWS 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Develop and implement a plan to quantify and monitor surviving populations. • Reintroduce and reestablish viable populations in other streams within the historical range that have suitable habitat and water quality. For example, the following streams were recommended by the Cumberlandian Region Mollusk Restoration Committee (2010): Alabama -Tennessee River main steam below tailwaters of Wilson Dam -Elk River -Paint Rock River Tennessee -Upper and Lower French Broad River -Upper and Lower Holston River -Lower Pigeon River -Buffalo River -Elk River • Conduct studies to determine the cause of the mussel die-offs in the Clinch River. • Continue to educate the public about water quality and freshwater mussels. (USFWS, 2020)

References

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee

USFWS 2007. Endangered and Threatened Wildlife and Plants

Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee

Final Rule. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461

USFWS 1983. Birdwing Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 56 pp. USFWS. 2020. Birdwing Pearlymussel Lemiox rimosus (Rafinesque, 1831). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 22 pp.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 31, 2016)

USFWS 1983. Birdwing Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 56 pp

USFWS 1983. Birdwing Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 56 pp.

USFWS. 1984. Birdwing Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 56 pp.

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office Cookeville, Tennessee.

USFWS 2011. Birdwing pearlymussel (Conradilla caelata [=Lemiox rimosus]) Dromedary pearlymussel (Dromus dromas) Cracking pearlymussel (Hemistena lata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Cookeville Ecological Services Field Office, Cookeville, Tennessee.

USFWS. 2020. Birdwing Pearlymussel Lemiox rimosus (Rafinesque, 1831). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Tennessee Ecological Services Field Office Cookeville, Tennessee. 22 pp.

SPECIES ACCOUNT: *Leptodea leptodon* (Scaleshell mussel)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The shell reaches a length of approximately 10 centimeters (4 inches), although old individuals may reach 12 centimeters (4 ¾ inches). The periostracum is smooth, yellowish green or brown, with numerous faint green rays (Figure 1). The shells are elongate, very thin, compressed, and rhomboidal. The anterior end is rounded. The dorsal margin is straight, and the ventral margin is gently rounded. Beaks are small and low, and nearly even with the hinge line. The beak sculpture, which may not be visible in older individuals, is inconspicuously compressed and consists of four or five double-looped ridges. The pseudocardinal teeth are reduced to a small, thickened ridge. The lateral teeth are moderately long with two indistinct teeth occurring in the left valve and one fine tooth in the right valve. The beak cavity is very shallow. The nacre is pinkish white or light purple and highly iridescent.

Taxonomy

The scaleshell is reported to have been first described by Rafinesque in 1820. However, there is some question whether his original description applies to the scaleshell. Clarke (1996) argues that the original description of the shell and abundance of the species better fits the pink papershell (Potamilus ohiensis) or possibly the cracking pearlymussel (Hemistena lata).

Historical Range

The scaleshell historically occurred in 56 rivers in 13 states within the Mississippi River Drainage. Williams et al. (1993) reported the historical range as Alabama, Arkansas, Illinois, Indiana, Iowa, Kentucky, Missouri, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin. Historical records also exist in Minnesota (Clarke 1996). While the scaleshell had a broad distribution historically, it apparently was not a common species locally (Call 1900, Baker 1928, Stansbery 1970, Gordon 1991, Oesch 1995, Clarke 1996). No quantitative data exist on the historic abundance of the scaleshell, but early descriptions of its distribution indicate that it was rare. Call (1900) considered the species “fairly common but not an abundant species” in the Ohio and Wabash rivers. Baker (1928) stated, “This is apparently a rare species in most places.” In describing the status of the scaleshell in the Mississippi River system, Stansbery (1970) wrote, “the expression ‘widespread and everywhere rare’ fits this species perfectly.” From our data requests conducted during this review, we discovered previously unknown Scaleshell records dated prior to 2011. A fresh-dead specimen was collected in 2005 from the convergence of Big Lake Relief (aka Stateline Outlet Ditch) and Ditch #3 (outflow below Big Lake National Wildlife Refuge structure) in northeast Arkansas (Christian 2006). While this species has not been found in this waterway before, it has been documented in an oxbow lake nearby within the Big Lake National Wildlife Refuge (Bouldin et al. 2013) (Table 1). Several museum specimens have been found that represent new historical rivers for the Scaleshell in Missouri and Arkansas. John H. Britts collected a specimen in 1899 from the Niangua River in Missouri (S. Faiman, Missouri Department of Conservation, pers com., November 1, 2016). The Nianuga River is a tributary of the Osage River where the Scaleshell was only discovered recently in 2001 (Table 1). There were several new museum specimens from Arkansas including an unnamed oxbow lake within the Big Lake National Wildlife Refuge (Mississippi County, 1974), two records with no date from the

Black River, and from the Boeuf River (Chicot County, 1979) (Bouldin et al. 2013) (Table 1). The five records discussed above (including the oxbow lake specimen) increase the total number of historical Scaleshell streams from 55 to 60. (USFWS, 2021)

Current Range

The scaleshell is believed to be extirpated from Minnesota, Iowa, Wisconsin, and all states east of the Mississippi River. Currently, the scaleshell can only be consistently found, although very rare, in three Missouri streams including the Meramec, Bourbeuse, and Gasconade rivers. It has been reported from 15 additional streams in the last 25 years, but only has been represented by a small number or a single specimen (live or dead) collected during one or more extensive mussel surveys of these rivers. These streams include the Big, Big Piney, Osage, and Missouri rivers in Missouri; Missouri River in South Dakota; Myatt Creek, St. Francis, White, Spring, South Fork Spring, Strawberry, South Fourche LaFave, Cossatot, Saline (a tributary of the Little River), and the Little Missouri rivers in Arkansas; and Kiamichi River in Oklahoma. In all, in the last 25 years, the scaleshell has been reported from 18 of the 56 rivers where it historically occurred. Overall, the species distribution remains the same as described in our 2011 review (USFWS 2011, Appendix II) and this information does not alter our understanding of the species' current distribution. The Meramec, Bourbeuse, and Gasconade rivers in Missouri are still considered the strong-hold populations for this species. (USFWS, 2021)

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Juvenile: Not much is known of the feeding behaviors of juvenile mussels. Juvenile mussels are believed to employ foot (pedal) feeding to some degree for the first several months of their lives, feeding on depositional materials in interstitial water, including bacteria, algae, and detritus (Yeager et al. 1994). Pedal feeding in juveniles is accomplished by movements of microscopic cilia lining the foot that carry food particles into the mantle cavity and into the mouth. Juveniles also use the foot in a sweeping motion to draw particles toward the mantle cavity (Reid et al. 1992).

Adult: Adults are suspension feeders, using their gills to remove suspended particles in the water column. While the diet of unionids is a subject of debate, it is believed to include detritus, phytoplankton, zooplankton, diatoms, bacteria, and other microorganisms (Fuller 1974). The extent of selectivity exhibited by mussels feeding on each of these food groups and species within these food groups is poorly understood and is likely to vary by species. Recent evidence suggests that detritus and bacteria may be an important food source (Silverman et al. 1997, Nichols and Garling 2000).

Reproduction Narrative

Adult: To better understand the discussions below related to the scaleshell's life cycle, it is first necessary to provide a general overview of the reproductive biology common to most freshwater mussels. Unionids have an unusual and complex mode of reproduction, which includes a brief, obligatory parasitic stage on fish. Most species typically have separate sexes, and spawning occurs in the spring, summer, or early fall (depending on the species). First, females lay eggs and brood them in specialized chambers in the gills (marsupia). Then males release sperm into the water column that are drawn into the female's incurrent siphon. Fertilization takes place internally within the marsupium. Within the marsupium, fertilized eggs develop into microscopic larvae (glochidia), which only have embryonic stages of a mouth, intestines, heart, and foot. The female may brood glochidia until the following year (long-term brooders) or release glochidia the same year it is fertilized (short-term brooder). Once glochidia are expelled by the female, they must quickly attach to the gills or the fins of an appropriate fish host to complete development. Glochidia that fail to attach to a suitable host will die. Host fish specificity varies among unionids. While some mussel species appear to require a single host species, other species can transform their glochidia into juvenile mussels on several fish species. Following proper host infestation, glochidia transform into juveniles, excyst from the host (drop off), and must settle into suitable habitat to survive. For further information on the life history of freshwater mussels, see Gordon and Layzer (1989), Watters (1995), and Parmalee and Bogan (1998). Specific information is available pertaining to the scaleshell's reproductive biology. Baker (1928) surmised that the scaleshell is a long-term brooder with spawning occurring in the fall and host infection in spring. Recent observations support Baker's conclusion. Gordon (1991) reported observations of gravid scaleshells in September, October, November, and March (location unknown). In Missouri, gravid specimens have been observed in the Meramec and Gasconade rivers in August, September, October, April, and June (Barnhart 2001, data from Roberts and Bruenderman 2000). Additionally, Barnhart (1998) observed the scaleshell in the Meramec River brooding undeveloped eggs in early August. The only known report of the scaleshell collected in a non-gravid condition is July from the Big River, Missouri (data from Roberts and Bruenderman 2000). Based on these observations, the scaleshell spawns and begins brooding in early August, and glochidia are released the following June in Missouri. Formal studies are needed to better define the breeding season of the scaleshell. These studies should be based on water temperature, in addition to season, as a controlling factor of its reproductive cycle. The glochidia of the scaleshell are among the smallest in the family Unionidae. A specimen from the Meramec River, Missouri, produced glochidia with an average length and height of 0.0676 and 0.0810 millimeters respectively (Barnhart 1998). The glochidia are semi-elliptical, rounded in the ventral margin, and have a short hinge line, which is typical for the subfamily Lamsilinae (Figure 6). The fact that they are hookless suggests that they are more adapted to attach to the gill of its host. Some unionid species (mainly in the subfamily Anodontinae) have hooked glochidia, which is an adaptation to attach firmly and transform on the fins of hosts (Howard and Anson 1922, Hoggarth and Gaunt 1988). Scaleshell glochidia are brooded by the female in the outer gills. The marsupia occupy the posterior part of the outer pair of gills, and when gravid, extends beyond the original edge of the gills. This observation is similar to Utterback's (1915) description of L. fragilis. Although the scaleshell is small, it has a high fecundity compared to many species. A small female collected from the Gasconade River with a length, width, and height of 44.1, 11.2, and 21.0 millimeters, respectively produced an estimated 419,000 glochidia (Barnhart 2001). For comparison, a Plea's mussel (Venustachoncha pleasii) of similar size produced approximately 46,947 glochidia, and a giant floater (Pyganodon grandis) with a length, width, and height of 125.5, 81.1, and 56.5 millimeters respectively produced about 235,210 glochidia (Barnhart2001). The small size of the scaleshell's glochidia may contribute to its ability to produce large numbers of larvae (Barnhart 2001). Unionids vary in their host specificity. Some mussel species can use a variety of fish species as hosts, but are usually limited to one or two families of fishes. A small number of mussels appear to be limited to a single fish host. The scaleshell appears to utilize the freshwater drum (Aplodinotus grunniens) exclusively as a host for its larvae. Barnhart (1998) tested 24 fishspecies and one amphibian, the mudpuppy (Necturus maculosus maculosus), as potential fish hosts in the laboratory. Glochidia only remained attached and transformed into juvenile mussels on the freshwater drum. Other species in the genus Leptodea and a closely related genus Potamilus are also known to use freshwater drum exclusively as a host (Watters 1994, Barnhart and Roberts 1997a, Roe et al. 1997, Barnhart 1998). While all available evidence suggests that drum is the host for the scaleshell, it still is considered a potential host until drum with natural infestations of scaleshell glochidia are observed in the wild. The successful transfer of mature glochidia to a suitable host constitutes one of the critical events in the life cycle of freshwater mussels, and various adaptations to facilitate this process have evolved. The method of host infection greatly varies among species. While some species simply release glochidia into the water where they must haphazardly come into contact with the appropriate host, the process is more intricate and direct in other species. For example, females in the genus Lampsilis have an extension of the mantle tissue that strikingly resembles a small fish. This structure is displayed outside the shell from between the valves and is twitched repetitively to attract its predaceous fish host. The host is infested by the female mussel when the fish attempts to eat the lure (Kraemer 1970, Barnhart and Roberts 1997b). Other unionid species release conglutinates (small structures made up of gelatinous material that enclose large numbers of glochidia) freely into the water. These structures resemble prey items of the mussel’s host fish; the host fish are infested when they attempt to eat them (Chamberlain 1934, Barnhart and Roberts 1997b). How a scaleshell infests its host and the intricacy of this relationship is unknown. One interesting hypothesis is that the scaleshell infests drum via host predation of females (Barnhart 2001). The small size, sexual dimorphism, apparent rarity of females, and the fact that freshwater drum are molluscivores support this hypothesis. Furthermore, the scaleshell produce glochidia at a small size and young age, which may be another adaptation for consumption by drum (Barnhart 1998). Knowledge of how the scaleshell infests its host and what environmental conditions in the stream might facilitate this interaction might shed light on possible reasons for recruitment failure. Once attached to its host fish, the scaleshell will disperse with the fish for a period of weeks while they must successfully transform. This phase is another major bottleneck in the life cycle of unionids as not all glochidia that attach to a suitable host successfully transform into juveniles. Barnhart (2003) reported a transformation period for scaleshell glochidia of between two and three weeks on freshwater drum. In these laboratory infestations, most developing glochidia remained encysted on drum for 16 to 20 days in water 25.5° C (77.9 °F). Transformation success of the glochidia varied widely on individual drum, ranging from 0 to 82%. This variation is unexplained and warrants further research. Genetics, age, and acquired immunity from previous parasitic infestations are

Geographic or Habitat Restraints or Barriers

Larvae: dams

Juvenile: dams

Adult: dams

Spatial Arrangements of the Population

Larvae: clumped according to suitable resources

Juvenile: clumped according to suitable resources

Adult: clumped according to suitable resources

Environmental Specificity

Larvae: specialist

Juvenile: specialist

Adult: specialist

Site Fidelity

Larvae: depended on host's movement

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The scaleshell occurs in medium to large rivers with low to medium gradients. It inhabits a variety of substrate types, but is primarily found in stable riffles and runs with slow to moderate current velocity. Buchanan (1979, 1980, 1994) and Gordon (1991) reported it from riffle areas with substrate consisting of gravel, cobble, boulder, and occasionally mud or sand. Call (1900), Goodrich and Van der Schalie (1944), and Cummings and Mayer (1992) reported collections from muddy bottoms of medium-sized and large rivers. Oesch (1995) considered the scaleshell a typical riffle species, occurring only in clear, unpolluted water with good current. Oesch also noted that it frequently buries itself in gravel to a depth of four to five inches. The scaleshell is also usually found in stable channels where a diversity of other mussel species are concentrated (i.e. mussel bed). This is typical for many other mussel species as suitable stream habitat for freshwater mussels naturally occurs in relatively small patches separated by longer reaches of unsuitable habitat (Vaughn and Taylor 2000, Vaughn and Pyron 1995, Strayer et al. 2004). Roberts and Bruenderman (2000) collected the scaleshell primarily from mussel beds with stable, gravel substrates. The habitat observations discussed above are consistent with the current distribution of the scaleshell; the species is restricted to streams that have maintained relatively good water quality and to stream reaches with stable channels. More specific physical, chemical, and biological habitat requirements of the scaleshell are unknown, particularly of the juvenile stage. As discussed above, the scaleshell appears to be dependent solely upon freshwater drum to complete its life cycle. Drum are common in larger streams throughout the range of the scaleshell. Drum live most of their lives on or near the bottom, and are usually found in large pools (Pflieger 1997). Their diet consists primarily of fish, crayfish, and immature aquatic insects (Daiber 1953, Moen 1955, Priegel 1967). Additionally, drum are capable of crushing mollusk shells with their heavy pharyngeal teeth and are believed to feed on small freshwater mussels and other mollusks. Spawning of drum is believed to take place in open water and eggs float for one or two days until hatching (Daiber 1953). In Missouri, freshwater drum migrate out of large rivers and reservoirs into tributary streams to spawn in late April and May (Pflieger 1997). Knowledge on the distribution, abundance, habitat use, and behavior of freshwater drum is needed to manage scaleshell populations and determine suitable habitat for reintroduction of the species.

Dispersal/Migration

Motility/Mobility

Larvae: Dependent on host

Juvenile: Limited; passive movement via flushing event

Adult: Limited; passive movement via flushing event

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Non-migratory

Adult: Non-migratory

Dispersal

Juvenile: Limited; passive movement via flushing event

Adult: Limited; passive movement via flushing event

Dependency on Other Individuals or Species for Dispersal

Larvae: yes; host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Adult: Adult unionids spend their entire lives partially or completely buried in the stream bottom (Murray and Leonard 1962). The depth to which they bury themselves may depend on the species, season, and environmental conditions (Parmalee and Bogan 1998). The posterior margin of the shell is usually partially spread, and the siphons extended to facilitate feeding and respiration. During periods of activity, movement is accomplished by extending and contracting a single muscular foot between the valves. Extension of the foot also enables the mussel to wedge itself into the river bottom. In the case of the scaleshell, it has frequently been observed living nearly or completely buried in the substrate to a depth of 13 centimeters (five inches) (Buchanan 1980, Oesch 1995, Roberts and Bruenderman 2000). In other circumstances, it has been found residing on the surface (Roberts and Bruenderman 2000, Bruenderman et al. 2001). The behavior of the scaleshell with respect to the extent of its activity level, vertical migration in the substrate, and seasonal movements is not well understood.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
unknown

Number of Populations:
very few (1 to 3)

Population Size:
unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
The scaleshell mussel (Leptodea leptodon) is a federally listed, endangered species that once occurred in 56 rivers in the Mississippi River Drainage. The species has undergone a dramatic reduction in range and is believed to be extirpated from 9 of the 13 states it historically occurred in. While the species has been documented from 18 streams in the last 25 years, it can only be found consistently in three streams in Missouri where it is still very rare. Since 2011, the Scaleshell has been reported from several streams within its historical range (Table 1). In 2013, an Illinois Natural History Survey biologist found a living Scaleshell in the Illinois River (K. Lundh, U.S. Fish and Wildlife Service, pers comm., May 17, 2013). This specimen was found during exceptional conditions during which the water was drawn down in the river, causing emersion of mussel populations. Prior to this record, the Scaleshell was considered extirpated from all historical streams east of the Mississippi River (USFWS 2010). Subsequent mussel surveys in the Illinois River failed to find additional evidence of the species (EA Engineering, Science and Technology, Inc., PBC 2014; Huff & Huff, Inc. 2015; EcoAnalysts, Inc. 2020; S. Schmuecker, pers comm., September 5, 2017 and January 4, 2121; K. Cummings, Illinois Natural History Survey, pers comm., January 26, 2021). In Missouri the last known collections are from the Meramec, Bourbeuse, and Gasconade rivers in 2019, and Big River in 2013 (Roberts et al. 2016) (Table 1). It was documented with a fresh dead shell in the Lower Osage River for only the second time during monitoring efforts in 2013 (Roberts et. al. 2014). In Arkansas, three live male specimens were found in 2017 in the Strawberry River (Gonzalez 2018) and a dead specimen the South Fourche LaFave River in 2019 (Chris Davidson, USFWS, personal communication, May 1, 2020)

(Table 1). These records confirm the persistence of very small Scaleshell populations in these streams. (USFWS, 2021)

Threats and Stressors

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Mussel biologists generally agree that contaminants are partially responsible for the decline of mussels [Havlik and Marking 1987, Bogan 1993, Williams et al. 1993, The National Native Mussel Conservation Committee (NNMCC) 1998]. Mussels are sedentary filter feeders and are vulnerable to contaminants that are dissolved in water, associated with suspended particles, or deposited in bottom sediments (Naimo et al. 1992). Mussels appear to be among the most sensitive organisms to heavy metals (e.g. cadmium, chromium, copper, mercury, zinc) some of which are lethal even at low levels (Havlik and Marking 1987, Keller and Zam 1991, Wang et al. 2007a, Wang et al. 2007b). Mussels are also sensitive to ammonia (Augspurger et al. 2003, Wang et al. 2007a, Wang et al. 2007b), which is a common pollutant in streams associated with animal feedlots, nitrogenous fertilizers, and the effluents of municipal wastewater treatment plants (Goudreau et al. 1993). Contaminants enter streams from point and nonpoint sources. Point source pollution is the entry of material from a discrete, identifiable source such as industrial effluents, sewage treatment plants, solid waste disposal sites, and accidental chemical spills. Industrial and municipal effluents often contain heavy metals, ammonia, chlorine, phosphorus, and numerous organic compounds. Direct freshwater mussel mortality from toxic spills and polluted water is well documented (Ortmann 1909, Baker 1928, Cairns et al. 1971, Goudreau et al. 1988). Decline and elimination of populations may be due to acute and chronic toxic effects that result in direct mortality, reduced reproductive success, or compromised health of the animal or host fish. Nonpoint source pollution is the entry of material into the environment from a diffuse source such as runoff from urban areas, cultivated fields, pastures, private wastewater effluents, agricultural feed lots and poultry houses, active and abandoned mines, construction, and highway and road drainage. Stream discharge from these sources may accelerate eutrophication (i.e., organic enrichment), decrease oxygen concentration, increase acidity and conductivity, and cause other changes in water chemistry that are detrimental to the survival of unionids and may impact host fishes (Fuller 1974, Dance 1981, Goudreau et al. 1988). Eutrophication generally occurs when nutrients are added in concentrations that cannot be assimilated as a result of runoff of organic wastewater contaminants from live stock farms and fertilizers used on row crops. Excessive growths of filamentous algae alter the surface of the stream bottom and may cause shifts in algal communities, disrupting food supplies for mussels. Juvenile mussels, utilizing interstitial habitats, are particularly affected by excessive levels of oxygen-consuming algae during nocturnal respiration (Sparks and Strayer 1998). Pesticides from row crops are a major source of agricultural contaminants, and are known to have direct affect on mussels (Havlik and Marking 1987).

Stressor: Sedimentation
Exposure:
Response:
Consequence:

Narrative: Sediment is material that is suspended in the water, and is being transported, or has been moved, as the result of erosion [U.S. Soil and Conservation Service (USSCS) 1988]. Although sedimentation is a natural process, intensive agricultural practices, channelization, impoundments, timber harvesting within riparian zones, heavy recreational use, urbanization, and other land use activities can accelerate erosion (Chesters and Schierow 1985, Myers et al. 1985, Waters 1995, Watters 2000). The water quality impacts caused by sedimentation are numerous. Generally, it affects aquatic biota by altering the substratum and by altering the chemical and physical composition of the water (Ellis 1936, Myers et al. 1985, USSCS 1988). Heavy sediment loads can directly affect freshwater mussel survival by interfering with respiration and feeding. Due to their difficulty in escaping smothering conditions (Imlay 1972, Aldridge et al. 1987), either sudden or gradual blanketing of the stream bottom with sediment can suffocate freshwater mussels (Ellis 1936). Sediment particles may carry contaminants toxic to mussels (Naimo et al. 1992). Increased sediment levels may also reduce feeding efficiency (Ellis 1936), which can lead to decreased growth and survival (Bayne et al. 1981).

Stressor: Channelization, sand and gravel mining, and dredging operations
Exposure:
Response:
Consequence:
Narrative: Channelization, sand and gravel mining, and dredging operations physically remove mussels from the water and may also bury or crush mussels (Watters 2000). More lasting effects of these activities involve the alteration or destruction of important unionid habitat that can extend upstream and downstream of the excavated area. Headcutting, the upstream progression of stream bed destabilization and accelerated bank erosion, can affect an area much larger than the dredging site (Hartfield 1993). In severe cases, this erosional process can extend for several miles upstream. As relatively immobile bottom-dwelling invertebrates, mussels are particularly vulnerable to channel degradation (Hartfield 1993). Accelerated erosion also releases sediment and pollutants, and in some instances, diminishes mussel diversity and habitat as documented in the Yellow and Kankakee Rivers in Indiana, the Big Vermillion River in Illinois, and the Ohio River (Fuller 1974).

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: Impoundments negatively affect mussels both upstream and downstream by inducing bank and channel scouring, altering water temperature regimes, and altering habitat, food, and fish host availability (Caryn Vaughn, in litt. 1997). Impoundments permanently flood stream channels and eliminate flowing water that is essential habitat for most unionids, including the scaleshell (Fuller 1974, Oesch 1995). Scouring is a major cause of mussel mortality below dams (Layzer et al. 1993). Most detrimental, however, is the disruption of reproductive processes. Impoundments interfere with movement of host fishes, alter fish host assemblages, and isolate mussel beds from each other and from host fishes (Stansbery 1973, Fuller 1974, Vaughn 1993, Williams et al. 1993). The result is diminished recruitment (Layzer et al. 1993). Dams are effective barriers to fish host movement and migration, which unionids depend on for dispersal. Fish movements are essential for maintaining scaleshell populations in streams where local extirpation occurs as a result of environmental extremes (e.g. drought and predation) or other factors. Further, mussels living upstream from a dam can become reproductively isolated from

those living downstream, causing a decrease in genetic diversity locally. On a smaller scale, even small, low head dams and low water crossings constructed across the stream channel can hinder fish movement between suitable habitats and isolate mussel populations from fish hosts and from each other. Watters (1996) determined that the upstream distribution of two mussel species, the fragile papershell (Leptodea fragilis) and pink heelsplitter (Potamilus alatus), stopped at lowhead dams. These species, like the scaleshell, are believed to use the freshwater drum as a sole host. Further, other structures constructed across the channel of in streams, such as low water road crossings, also hinder or block upstream dispersal of mussels. For example, the upstream distribution of the fat pocketbook (Potamilus capax) was found to stop at a fishweir in Southeast Missouri (Roberts et al. 1997).

Stressor: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes
Exposure:
Response:
Consequence:
Narrative: It is unlikely that commercial mussel collectors ever purposefully collected the scaleshell because of their small size and thin shell. It is probable, however, that over-harvesting activities impacted scaleshell populations as it has been shown to cause declines in non-commercial species (Anthony and Downing 2001). For example, according to local fishermen, during a period of extended drought, mussel harvesters severely over-harvested mussel beds in the Spring and Black Rivers and completely destroyed most beds (Gordon et al. 1984). Commercial harvest is believed to have contributed to mussel declines in the Poteau River, Oklahoma. Vaughn and Spooner (2004) observed piles of discarded mussels left to die from harvesting activities in very shallow water or streamside in the Poteau. In areas where commercial or other harvest has taken place, scaleshell populations may have been impacted by habitat destruction (i.e., disturbance of stream bottom), trampling, and removal of individuals from the stream. Individuals dislodged from the stream bottom could be washed away into unsuitable habitat, particularly because the scaleshell is a relatively light mussel in the water due to its small size and thin shell. Even for mussels returned to the stream, mortality can still occur (Cochran and Layzer 1993, Williams et al. 1993). Further, the removal of large numbers of commercial species such as the washboard (Megalonaias nervosa) may adversely affect other mussel species because in large numbers mussels stabilize the streambed, thus increasing the habitat suitability for other species. Also, commercial species perform ecosystem functions that provide habitat for and facilitate other species (Vaughn and Hakenkamp 2001, Spooner 2002). Today, intensive mussel collecting activity can have adverse affects on existing populations, because the scaleshell now occur in very small, isolated areas. The destruction of only a few individuals could be a contributing factor in the extirpation of some populations. As the scaleshell become more uncommon, the interest of scientific and shell collectors may increase. Scaleshell occurrences are generally localized, easily accessible, and exposed during low flow periods, and, therefore, are also vulnerable to take for fish bait, curiosity, or vandalism. Prior to the listing of the scaleshell as an endangered species, up to five freshwater mussels per day could be legally collected in Missouri and used for fishing bait (MDC 2003). While this provision does not include federally listed species or state species of conservation concern, the scaleshell can easily be confused with other species, particularly by untrained collectors. However, the low density of scaleshell populations minimizes the likelihood of a scaleshell being collected.

Stressor: Disease or Predation
Exposure:

Response:
Consequence:
Narrative: Although natural predation is usually not a factor for stable, healthy mussel populations, small mammal predation could pose a problem for scaleshell populations (Gordon 1991). Small mammals, such as river otters, muskrats, and raccoons, are common predators of the scaleshell throughout their range, particularly during periods of low water providing easy access to mussel beds. These mammals are so effective at finding and eating freshwater mussels that malacologists consider collecting dead shells from middens a good way to determine the presence of rare species. For example, freshly killed scaleshell specimens were found among other species at several sites with active raccoon middens during a freshwater mussel survey of the Meramec and Bourbeuse Rivers (Roberts and Bruenderman 2000). Muskrat predation has been shown to be potentially detrimental to the recovery of rare mussels (Neves and Odom 1989). While the large size or thick shells of some species afford protection from small mammal predators, the small size and fragile shell of the scaleshell makes it an easy and desirable prey species. Extant scaleshell populations in Arkansas and Oklahoma are small, isolated, and have very limited recolonization potential. Thus, the removal of even a small number of individuals could significantly affect these populations. Small populations are less resilient to these natural predators, and therefore, are much more threatened by them. Consequently, predation could exacerbate ongoing population declines of the scaleshell. Bacteria and protozoans persist at unnaturally high concentrations in streams with high sediment load or in water bodies affected by point source pollution, such as sewage treatment plants (Goudreau et al. 1988). At such concentrations, mussel ova and glochidia are more subject to infection (Ellis 1929). Disease and parasites may have caused major die-offs of freshwater mussels in the late 1970s throughout the eastern United States (Neves 1986). For example, significant die-offs of freshwater mussels occurred in 1977 and 1978 in the Meramec and Bourbeuse Rivers. Large numbers of mussels of all species, including the scaleshell, were lost. Buchanan (1986) presumed an epizootic or other disease caused the die-off since no environmental impact was reported or could be found. Little is known about predators of juvenile mussels. As microscopic inhabitants in the bottom of the stream, juvenile freshwater mussels probably fall prey to a variety of macroinvertebrate predators such as hydra, various aquatic insect larvae, and crayfish. Flatworms have been shown to be voracious predators of newly metamorphosed juvenile mussels (Barnhart 2002, Delp 2002, Zimmerman and Neves 2003). However, juvenile mussels grow rapidly and can exceed the size of these tiny predators (Barnhart 2002, Delp 2002).

Stressor: Inadequacy of Existing Regulatory Mechanisms
Exposure:
Response:
Consequence:
Narrative: The passage of the Clean Water Act (CWA) resulted in many positive consequences for freshwater ecosystems (including a decrease in lead and fecal coliform bacteria), and set the stage for the regulations and the water standards that exist today. Goals of the CWA include the protection and enhancement of fish, shellfish, and wildlife providing conditions suitable for recreation in surface waters and eliminating the discharge of pollutants into U.S. waters. However, despite the implementation of the CWA, degraded water quality still presents problems for sensitive aquatic organisms such as freshwater mussels. Specifically, nationwide stream and lake sampling has indicated continuing increases in nitrate, chloride, arsenic, and cadmium concentrations (Neves 1993). In recent studies, mussels have been found to be very sensitive to ammonia, which is one of the most common pollutants in streams (Augspurger et al.

2003, Wang et al. 2007a, Wang et al. 2007b). These studies have called into question if the Environmental Protection Agency's (EPA) current national water quality criteria are protective of freshwater mussels because those criteria were derived from a toxicity database predating the recent data available for freshwater mussels. Nonpoint pollution sources appear to be the cause of increases in nitrogen. Many of the impacts discussed above occurred in the past as unintended consequences of human development. Improved understanding of these consequences has led to regulatory (e.g., CWA) and voluntary measures (e.g., best management practices for agriculture and silviculture) and improved land use practices that are generally compatible with the continued existence of the scaleshell. Nonetheless, the scaleshell is highly restricted in numbers and distribution and shows little evidence of recovering from historical habitat degradation and losses. In 1997, gravel mining became a more serious threat for the scaleshell range-wide when a court ruling (American Mining Congress versus USACE) changed the interpretation of the CWA as it applies to the regulation of gravel mining (Roell 1999). Previously, gravel mining was more strictly regulated because “incidental fallback” (the incidental soil movement from excavation, such as the soil that is disturbed when dirt is shoveled, or back-spill that comes off a bucket and falls into the same place from which it was removed) was considered fill in surface waters, thus triggering the permitting process of the USACE under Section 404 of the CWA. Prior to the 1997 ruling, gravel mining operators were required to obtain a USACE Section 404 permit and follow several conditions outlined on the permit. Except in very small tributaries, the USACE required all operators to establish a streamside and riparian buffer and prohibited removing gravel from flowing water (i.e., no in-stream mining) or from below the water table (Danny McClendon, USACE, St. Louis District, pers. comm. 1998). These requirements avoided most adverse effects to mussels including headcutting, channel modification, and the physical crushing or removal of mussels. Furthermore, the USACE's permit process included consultation with the USFWS concerning the presence of federally listed species at each proposed mining site. However, the 1997 ruling eliminated the USACE' authority to regulate most instream gravel mining activities, thereby eliminating the section 404 permit and the conditions that protected mussel beds. Therefore, the scaleshell has lost much of its protection from gravel mining. The USACE will still retain oversight authority and require a permit for gravel mining activities that deposit fill into streams greater than incidental fallback under Section 404 of the CWA (i.e. instream gravel stockpiling, stream crossings, and select removal methods). A USACE permit would also be required under Section 10 of the Rivers and Harbors Act for navigable waterways. However, many gravel mining operations do not fall under these two categories. The Missouri Department of Natural Resources (MDNR) is currently responsible for regulating gravel mining in Missouri, but has limited regulatory authority. City, county, and state operators using their own equipment and private operations are not required to obtain a MDNR permit for instream gravel mining. In Arkansas, instream gravel mining will still be controlled by the Arkansas Open-Cut Mining and Land Reclamation Code, which contains required conditions to reduce impacts (Roell 1999). Additionally, since MDNR is not a federal agency, Section 7 of the ESA, which required the USACE to consult with the USFWS regarding the presence of federally listed species at proposed gravel mining sites, is no longer applicable. Without the section 7 consultation process, mussel beds containing federally listed species could be adversely affected by gravel mining operations. Although recognized by species experts as threatened in the state of Arkansas, the scaleshell has not been afforded state protection prior to becoming federally listed as an endangered species. Missouri and Oklahoma previously listed it a species of conservation concern (Sue Bruenderman, in litt. 1998; Caryn Vaughn, pers. comm. 1995). However, these designations were primarily used for planning and communication purposes and did not afford any significant state protection from direct take and habitat destruction (David Martinez, pers.

comm. 1997; Paul McKenzie, USFWS, Columbia, MO, pers. comm. 1997).

Stressor: Biological traits
Exposure:
Response:
Consequence:
Narrative: The inherent biological traits of freshwater mussels increase their vulnerability to extinction (Neves 1993). Their complex life cycle offers many opportunities for reproduction to fail including incomplete fertilization due to low density upstream populations, failure to attach to the appropriate fish host, and unsuccessful transformation on the fish host. If a larva successfully transforms on a host, it is further challenged with dropping off into suitable habitat. Estimated chances of successful glochidial transformation and excystment (detachment) range between 0.0001 percent (Jansen and Hanson 1991) and 0.000001 percent (Young and Williams 1984). As a result of fish host-specificity and the difficulty of locating suitable habitat, even under optimal conditions, freshwater mussel population growth occurs very slowly. Furthermore, the sedentary nature of mussels limits their dispersal capability. This trait, coupled with low recruitment success, translates into the need for decades of immigration and recruitment for re-establishment of self-sustaining populations.

Stressor: Population size and habitat fragmentation
Exposure:
Response:
Consequence:
Narrative: The small number and low density of the remaining scaleshell populations exacerbate threats to its survival posed by the natural and manmade factors discussed above. Although the scaleshell was always locally rare though broadly distributed, the widespread loss of populations and the limited number of collections in recent years indicates that the current population densities are much lower (due to the previously identified threats) than historical levels. Despite any evolutionary adaptations for rarity, habitat loss and degradation increase a species' vulnerability to extinction (Noss and Cooperrider 1994). Similarly, as the number of occupied sites decreases, and the likelihood of extinction increases (Vaughn 1993). This increased vulnerability is the result of chance events. Environmental variation, random or predictable, naturally causes fluctuations in populations. However, small and low density populations are more likely to fluctuate below the minimum viable population (i.e., the minimum number of individuals needed in a population to persist) (Szymanski 1998). If population levels stay below this minimum size, an inevitable and often irreversible slide toward extinction will occur. Further, the shorter life span of the scaleshell may render it less able to tolerate periods of poor recruitment or increased mortality than longer-lived mussel species (Barnhart 2001). Similarly, the fertilization success of females may be related to population density, with a threshold density required for any reproductive success to occur (Downing et al. 1993). Many of the remaining scaleshell populations may be at or below this threshold density. Because females must siphon sperm released by males into the water column, successful spawning events depend on upstream males. Therefore, a low density or lack of upstream males can result in incomplete fertilization of females. In 2002, a gravid female scaleshell collected from the Meramec River Basin, Missouri was observed to be only partially fertilized (Dr. M.C. Barnhart, pers. comm. 2003). This individual is one of only a few females in which the gill contents were examined under a microscope to determine the developmental condition of the eggs. The incomplete fertilization of this female may be an indication that spawning failures may be occurring because small

populations may have individuals too scattered to reproduce effectively. These populations will be, if the aforementioned threats go unabated, forced below or forced to remain below the minimum threshold. As a result, reproduction is diminished or ceases, and the current decline to extinction will be accelerated. Species that occur in low numbers must rely on dispersal and immigration for long-term persistence. In order to retain genetic viability and guard against chance extinction, movement between populations must occur. Although the scaleshell naturally occurs in patches within a river and necessarily possesses mechanisms to adapt to such a discontinuous distribution, anthropogenic (man-made) influences have fragmented and further lengthened the distance between occupied patches of suitable habitat. Empirical studies have shown that with increasing isolation, immigration and colonization rates decrease. Also, as previously explained, natural recolonization of mussels occurs at a very low rate (Vaughn 1993). Therefore, preservation of a population (including all partially isolated patches in a river) structure is imperative for longterm freshwater mussel survival. Unfortunately, many of the extant scaleshell populations now occur as single, isolated sites. These highly isolated populations are very susceptible to natural stochastic events and human-induced environmental change.

Stressor: Drought
Exposure:
Response:
Consequence:
Narrative: Severe drought is a natural event that can have devastating effects on freshwater mussels because of their inability to escape adverse environmental conditions. Because the scaleshell is primarily a riffle species, many extant scaleshell sites are in relatively shallow water. This makes some local populations susceptible to exposure during drought conditions. For example, unusually low water in 2000 caused the partial exposure of several mussel beds containing the scaleshell in the Gasconade and Meramec River basins (Bruenderman, pers. comm. 2000). Concentrations of mussels, particularly around the peripheral edges of mussel beds, were exposed for long periods. Based on fresh dead shells collected from these areas, a number of scaleshells and many other species died from desiccation. While some thick-shelled mussel species can survive emersion for extended periods, the thin shell of the scaleshell and its inability to close its valves completely makes it especially vulnerable to emersion (Dr. M.C. Barnhart, pers. comm. 2004). Low water also allows raccoons and other small mammals that prey on mussels to gain easy access to mussel beds.

Stressor: Non-native species
Exposure:
Response:
Consequence:
Narrative: The introduction of non-native freshwater bivalves into the United States has contributed to the decline of the native mussel fauna. The recent invasion of the exotic zebra and quagga mussels (Dreissena polymorpha and D. bugensis) pose a substantial threat to native unionids (Herbert et al. 1989). The introduction of Dreissena into North America probably resulted from an ocean-crossing vessel that discharged freshwater ballast from Europe containing free-swimming larvae (Griffiths et al. 1991). Since the introduction of these species, the zebra mussel has proved to be more widespread and abundant. Since the discovery of zebra mussels in North America in Lake St. Clair of the Laurentain Great Lakes in 1988, this prolific species has spread throughout the Mississippi River and many of its tributaries including the

Illinois and Ohio basins and the Arkansas (into Oklahoma and Kansas) and Tennessee rivers. Zebra and quagga mussels have effective dispersal mechanisms, which has facilitated their spread in the United States. Because zebra mussels attach themselves to hard surfaces, they can spread by attaching and living on commercial and recreational vessels. The free swimming, microscopic larva spread naturally downstream of reproducing populations. The larva are also transported from infected waters via bait buckets and live wells of recreational boats and introduced into new areas. Zebra mussels starve and suffocate native mussels by attaching to their shells and the surrounding habitat in large numbers. The spread of this prolific species has caused severe declines of native freshwater mussel species in many areas (Tucker et al. 1993; Kent Kroonemeyer, USFWS in litt. 1994; Illinois Natural History Survey, in litt. 1995; USACE, in litt. 2000). The threat posed by zebra mussels appears to be imminent for the largest remaining populations of the scaleshell. In 1999, a live zebra mussel was collected at river mile 6.9 in the lower Meramec River (Dr. M.C. Barnhart, in litt. 1999). Veligers have been found in Missouri River in Nebraska, indicating the existence of a reproducing population. If zebra mussels successfully colonize the Missouri River, it is likely that they will eventually spread into the Gasconade River (a tributary of the Missouri), which has perhaps the largest population of the scaleshell next to those in the Meramec Basin. Populations in navigable rivers and downstream from reservoirs (e.g., White and Osage Rivers) are particularly vulnerable due to commercial and recreational vessels that utilize these water bodies, which will hasten the invasion. In 2006, an established zebra mussel population was discovered in Lake of the Ozarks and live individuals found subsequently at two locations on the Osage River in Missouri (Steve McMurray, MDC, in litt. 2006). This population was likely introduced by boats. Zebra mussels have spread throughout much of the Mississippi River Basin, but at this time, no large, established populations are known to occur in streams occupied by the scaleshell. However, they are likely to invade these streams based on the proliferation and spread that has already occurred. Many rivers within the scaleshell's extant range are similar in most ways to other tributaries of the Mississippi River with established zebra mussel populations. The Asian clam (Corbicula fluminea) is another freshwater bivalve that has been introduced into North America. It was first discovered in the United States in the late 1930's (Oesch 1995). Its prolific reproductive capability has allowed it to quickly spread its range across the continent, and the species is now almost ubiquitous throughout the range of the scaleshell. The Asian clam can become the dominant benthic species as densities of several hundred to 10,000/m2 have been reported in some rivers (Neves 1986, Sickel 1986). The species is believed to compete with native mussels for resources such as food, nutrients, and space (Kraemer 1979, Clark 1986). High densities of Asian clams have been found to negatively affect the survival and growth of juvenile native mussels by disturbance and displacement of young juveniles and possibly through incidental ingestion of newly metamorphosed individuals (Yeager et al. 2000). Further, Corbicula populations can grow rapidly and are prone to rapid die-offs (McMahon and Williams 1986), which can affect native mussels by depleting the oxygen supply and by producing high levels of ammonia (Strayer 1997). The black carp (Mylopharyngodon piceus) poses a significant threat to the scaleshell in the near future. Native to Eastern Asia, black carp were accidentally brought into the United States in the early 1970s by the aquaculture industry while importing other Chinese carp stocks. Subsequent introductions occurred in the early 1980's as the species was imported as a food fish and as a biological control for yellow grub (Clinostomum margaritum) in aquaculture ponds (Nico et al. 2005). The number of reports of black carp captured in Arkansas, Illinois, Mississippi, and Missouri suggests that the species may be established and reproducing in the wild (Nico et al. 2005). Because black carp feed on freshwater mollusks extensively, it poses a major threat to the native freshwater mussel fauna if allowed to escape into the wild and establish reproducing populations (Nico and Williams

1996). A four year old black carp was shown to eat an average of 3-4 pounds of mussels per day (USFWS 2002a). Smaller mussels (e.g. the scaleshell) and juvenile recruits are probably most vulnerable to being consumed by black carp (Nico et al. 2005). If wild populations are established, the black carp is likely to proliferate in North America as other related, non-native carp have such as the grass carp (Ctenopharyngodon idella) (Nico and Williams 1996). Currently, there appears to be no existing, economically feasible method to eliminate black carp once they escape into large river systems (Nico et al. 2005).

Recovery

Reclassification Criteria:
1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, four stream populations exist, each in a separate watershed and each made up of at least four local populations located in distinct portions of the stream. Each stream population must exist in a separate watershed so that a single stochastic event, such as a toxic spill or disease outbreak, will not affect more than one of the four stream populations. This criterion is based on the available information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 (Research Population Dynamics of the Scaleshell) is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per the measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows. Step 1: Identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2). Step 2: Define measurable criteria for alleviating/reducing each of those threats and prioritize threats according to effects to local populations (Action 2.3). Step 3: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. Step 4: Track the progress of recovery implementation (Action 7.2).

Delisting Criteria:
1. Through protection of existing populations, successful establishment of reintroduced populations, or the discovery of additional populations, a total of eight stream populations exist, each in a separate watershed and each made up of at least four local and geographically distinct populations. At a minimum, one stream population must be located in the Upper Mississippi River Basin, four in the Middle Mississippi River Basin (two of these must exist east of the Mississippi River), and three in the Lower Mississippi River Basin. Completion of action 3.4.2 or 3.4.3 may indicate more local populations, streams, or geographical regions are required. This criterion is based on the available information and the best professional judgment of species experts (see Appendix v), and may be revised based on additional biological, demographic, or

genetic information obtained through Recovery Actions 3.1 and 3.4.

2. Each local population in Criteria 1 is viable in terms of population size, age structure, recruitment, and persistence. Currently, what constitutes a viable population of the scaleshell is not known. Population viability will be defined when Action 3.4.2 is completed. In the future, this criterion will be revised to incorporate the definition of population viability resulting from this recovery action (3.4.2).

3. Threats to local populations in Criterion 1 have been identified and addressed per measurable criteria developed in Action 2.3. Currently it is not feasible to identify in this criterion the specific threats to populations and thresholds at which those threats are reduced to the level where criteria 1 and 2 are achieved. However, the thresholds for this criterion will be defined through the implementation of key actions in the plan as follows. Step 1: Identify and map present and foreseeable threats to local populations in a GIS database (Action 2.2). Step 2: Define measurable criteria for alleviating/reducing each of those threats and prioritize threats according to effects to local populations (Action 2.3). Step 3: Apply the appropriate recovery actions outlined in this plan to alleviate/reduce threats. Step 4: Track the progress of recovery implementation (Action 7.2).

Recovery Actions:

- Recovery actions needed for the scaleshell include:
- 1) stabilize existing populations through artificial propagation to prevent extirpation;
- 2) formation of partnerships and utilization of existing programs to protect remaining populations, restore habitat, and improve surface lands;
- 3) improve understanding of the biology and ecology of the scaleshell;
- 4) further delineate the current status and distribution of the scaleshell;
- 5) restore degraded habitat in areas of historical range;
- 6) reintroduce the scaleshell into portions of its former range;
- 7) initiate various educational and public outreach actions to heighten awareness of the scaleshell as an endangered species and solicit help with recovery actions;
- and 8) track recovery and conduct periodic evaluations with respect to recovery criteria.
- Prior to becoming listed as a federally endangered species, the scaleshell was considered threatened in the state of Arkansas. However, this designation did not afford any legal protection for the species. Missouri and Oklahoma previously listed it as species of conservation concern. However, these designations were primarily used for planning and communication purposes and did not afford any significant state protection from direct take and habitat destruction.
- The Endangered Species Act of 1973, as amended, contains protection and recovery provisions for federally listed threatened and endangered species. Conservation measures provided to the scaleshell as an endangered species include recognition, recovery actions, requirements for federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness and conservation actions by Federal, State, and local agencies, private organizations, groups, and individuals. The ESA provides for possible land acquisition and cooperation with the State and requires that recovery actions be carried out for all listed species. The protection required of federal agencies and the prohibitions against certain activities involving listed species are discussed, in part, below.

- Section 6 of the ESA allows the USFWS to provide funds to States for the conservation of species. The USFWS also has the latitude to provide funding to private landowners and researchers interested in the conservation of the scaleshell mussel through discretionary monies and other sources as available. The USFWS's Partners for Fish and Wildlife Program can provide funding for habitat restoration or enhancement. Other funding sources are available through other federal agency programs such as the Farm Service Administration's (FSA), Conservation Reserve Program (CRP), and the National Resources Conservation Service's (NRCS) Forestry Incentives Program (FIP),Wetlands Reserve Program (WRP), Environmental Quality Incentives Program (EQIP), and Wildlife Habitat Incentives Program (WHIP) programs.
- Private landowners can also benefit from Safe Harbor Agreements which are voluntary arrangements between the USFWS and cooperating non-federal landowners. These agreements benefit endangered or threatened species while giving landowners assurances from additional restrictions. Following development of an agreement, the USFWS will issue an "enhancement of survival" permit, to authorize any necessary future incidental take to provide participating landowners with assurances that no additional restrictions will be imposed as a result of their conservation actions.
- Under sections 2(c)(1) and 7(a)(1) of the ESA2"Sec. 7. (a) federal Agency Actions and Consultations.- (1) The Secretary shall review other programs administered by her and utilize such programs in furtherance of the purposes of this ESA. All other federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this ESA by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this ESA.", all federal agencies within the range of the scaleshell, and in consultation with the USFWS, have a responsibility to develop and carry out programs for the conservation of this species.
- Section 7(a)(2) of the ESA, as amended, requires federal agencies to evaluate their activities with respect to any species that is proposed or listed as endangered or threatened. Regulations implementing the section 7 interagency cooperation provisions of the ESA are codified at 50 CFR Part 402. Section 7(a)(2) requires federal agencies to ensure activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the scaleshell mussel. If a federal agency's action is likely to adversely affect the scaleshell mussel, the responsible federal agency must initiate formal consultation with the USFWS. Federal agencies that may have jurisdictional responsibilities within the range of the scaleshell include, but is not limited to, the U.S. Forest Service, USACE, Federal Energy Regulatory Commission (FERC), Natural Resources Conservation Service (NRCS), U.S. Environmental Protection Agency (USEPA), Farm Services Administration, and Federal Highway Administration.
- Sections 9 and 10 of the ESA and their implementing regulations found at 50 CFR 17.21 set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. These prohibitions, in part, make it illegal for any person subject to the jurisdiction of the United States to take (including harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or attempt any such conduct), import or export, ship in interstate or foreign commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. It also is illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions apply to USFWS agents and those of State conservation agencies.

- Section 10 of the ESA and its implementing regulations codified at 50 CFR 17.22 and 17.23 provide for the issuance of permits to carry out otherwise prohibited activities involving endangered wildlife under certain circumstances. For endangered species, such permits are available for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities.
- The CWA was passed in 1972, and has greatly reduced the point-source discharge of pollutants into streams (Neves et al. 1997). Municipalities and industries have improved wastewater treatment facilities with grants and aid from the USEPA and State environmental protection departments. Nonpoint-source pollution is dealt with in a number of ways under the CWA, including providing funds through Section 319 nonpoint-source pollution program to improve water quality and reduce nutrient loading, sedimentation, and the likelihood of other pollutants entering streams. In addition, the States, USEPA, and U.S. Geological Survey (USGS) have assessed and monitored water quality in streams throughout much of the range of the scaleshell.
- Federal government involvement also includes the Fish and Wildlife Coordination Act (FWCA), which is intended to protect fish and wildlife resources and their habitats by coordinating with natural resource agencies on their projects. Programs under the U.S. Department of Agriculture (USDA), particularly those administered by the NRCS [e.g., Conservation Reserve Enhancement Program (CREP), EQIP, WRP, Fish and Wildlife Habitat Improvement Program], are increasingly addressing restoration of impaired streams with imperiled species. The NRCS is routinely adopting animal waste management plans to reduce nutrient and sediment input into streams throughout the country.
- The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) authorizes the USFWS and the National Oceanic and Atmospheric Administration to issue regulations preventing the unintentional introductions of aquatic nuisance species. On February 2, 1999, the President issued Executive Order (EO) 13112 on invasive species. The EO places increased emphasis on efforts to prevent the introduction of invasive species; to provide for their control; and to minimize the economic, ecological, and human health impacts that invasive species cause. Regulations under the NANPCA and the EO will help prevent the incidental importation of other mollusks that are harmful to native species. The USFWS has developed four priorities under the title “Director’s Priorities FY 1999-2000.” One of the priorities is to develop and implement an aggressive program to enhance the USFWS’s capability and leadership role to respond effectively to present and future invasive species problems and issues. All USFWS offices will focus efforts via three goal statements—enhance leadership, take direct action, and raise public awareness.
- As part of a memorandum of understanding with the USFWS, the Oklahoma Department of Environmental Quality (ODEQ) agreed to recognize a USFWS list of Aquatic Resources of Concern in Oklahoma. The list includes the Kiamichi River and Little River drainages in southeast Oklahoma, based on their inhabitation by federally listed species. The memorandum provides for the USFWS to receive special notification of proposed discharge permit actions pending before the ODEQ, where those actions involve waters listed as Aquatic Resources of Concern.
- The Oklahoma Department of Wildlife and Conservation amended its regulations to designate the Kiamichi River as a mussel sanctuary (9 Oklahoma Regulations 1909, effective January 1, 1993). Likewise, in 1997 and 2000, the Arkansas Game and Fish Commission designated the Ouachita River upstream of Camden as a mussel sanctuary. With this designation, these rivers are closed to all commercial harvest. It also provides additional

protection to the scaleshell and other federally listed species by prohibiting activities that might disrupt the species' habitats.

- Since the scaleshell was listed as an endangered species, several efforts have been made specifically to help conserve the species and improve its habitat. USFWS funds (i.e., discretionary and Section 6) and state funds have also been used to fund survey work in various portions of its range, ongoing monitoring of the species' population numbers, and conducting searches for additional populations. Since 1998 there have been several multi-year scaleshell projects funded through section 6 of the ESA that focused on producing and releasing artificially propagated juveniles into the wild in Missouri. The goal of these projects is to develop propagation methods and stabilize the most significant remaining populations of the scaleshell and other species through augmentation of existing populations. Unfortunately, propagation efforts have been limited by the availability of gravid females. Release sites include extant sites in the Meramec, Bourbeuse, and Gasconade rivers. Other release sites will depend on the collection location and availability of gravid females. This effort is intended to help stabilize populations while habitat improvements are implemented in these watersheds.
- Several habitat improvement projects have been completed within the Bourbeuse River Basin through the USFWS's Partners for Fish and Wildlife and the MDC's Private Lands Program in cooperation with volunteer private landowners. These actions involve the following land management actions that have made habitat and watershed improvements benefiting the scaleshell: 1) establishment of planned grazing systems to address overgrazing, 2) providing alternative watering sources away from streams and drainages to address cattle watering in streams, 3) reestablishing a protective riparian corridor to reduce erosion and sedimentation of streams and drainages, and 4) bank stabilization to reduce bank erosion, and 5) improving and reinforcing low water stream crossings to reduce stream bed erosion and improve fish passage. These efforts are just now getting underway at specific sites in the Bourbeuse River Basin.
- The USGS's Columbia Environmental Research Center is conducting a large-scale research project funded by the USFWS and USEPA to develop and apply methods to conduct toxicity tests for freshwater mussels (including the scaleshell). This study will 1) develop methods for conducting acute and chronic toxicity tests with glochidia and juvenile life stages of mussels, 2) evaluate the acute or chronic effects of ammonia, chlorine, and copper on glochidia and juvenile mussels (surrogates and listed species), and 3) develop American Society for Testing and Materials standards for conducting toxicity tests with freshwater mussels. The main focus of this study is to determine if USEPA's national water quality standards are protective of freshwater mussels to apply to the monitoring of point-source discharges of pollutants into streams.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: The recovery actions listed in the Scaleshell Recovery Plan are still applicable (USFWS 2010). Several of the priority actions listed are related to augmenting existing populations and reintroducing the species into portions of its historical range via artificial propagation (actions 2.5 and 5.0). Progress has been made within these recovery action categories since 2010, including the development of propagation and rearing methodologies for Scaleshell (Action 2.5.2) and the determination of genetic differentiation among and within populations (Action 3.4.1) (Chong and Roe 2017). Both of these actions are considered prerequisites for implementing a propagation program. The next step in this process is for the USFWS to develop a Scaleshell propagation and reintroduction plan with state and federal partners within the extant and historical range of the species (Action 2.5.1). In this plan, the USFWS would identify streams where threats have been alleviated and population augmentation or reintroduction might be appropriate. If carried out properly, a 3 propagation plan could make significant progress towards recovery and meeting the downlisting criteria for the species. (USFWS, 2021).

References

Recovery Plan

U.S. Fish and Wildlife Service. 2021. 5-YEAR REVIEW The Scaleshell Mussel (Leptodea leptodon). 17 pp.

Recovery Plan 2010

SPECIES ACCOUNT: *Margaritifera hembeli* (Louisiana pearlshell)

Species Taxonomic and Listing Information

Listing Status: Threatened; September 24, 1993; Southeast Region (R4) (USFWS 2011) Endangered; February 5, 1988; Southeast Region (R4) (USFWS 2011)

Physical Description

The shell surface has uneven growth lines and occasionally has faint sculpture lines on the posterior end. The epidermis is brown to blackish and the nacre is white to purple with numerous pits. Adults are about 100 millimeters (mm) (3.9 inches) long, 50 mm (2.0 inches) high and 30 mm (1.2 inches) wide (USFWS 1989).

Taxonomy

The Louisiana pearlshell mussel was described as Unio hembeli by Conrad in 1838. This species was placed in the genus Margaron by Lea (1870), then in Margaritana by Simpson (1900), and finally in Margaritifera by Athearn (1970). At that time, the Louisiana and Alabama pearlshell mussel were considered the same species, but the Alabama pearlshell mussel was subsequently elevated to species status (Margaritifera marrianae) based upon morphological and anatomical comparisons (Johnson 1983) (USFWS 2011).

Historical Range

The Louisiana pearlshell, is known from only the Bayou Boeuf drainage in Rapides Parish, Louisiana. The LNHP survey found the Louisiana pearlshell scattered in headwater streams of the Bayou Boeuf drainage. This suggests a historic range including most, if not all, of the Bayou Boeuf system. (USFWS 1989).

Current Range

The Louisiana pearlshell occurs in Grant and Rapides Parishes, Louisiana. Those streams drain into two Red River tributaries (i.e., Bayou Rigolette and Bayou Rapides) (Johnson and Brown 2000). The Red River is a tributary to the Mississippi River, while water from Bayou Boeuf eventually enters Vermilion Bay of the Gulf of America (USFWS 2011).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Mussels are also dependent upon the water currents to bring food particles within the range of their siphons (USFWS 1989). Adults are detritivores, while immature specimens are parasitic (NatureServe 2015).

Reproduction Narrative

Adult: Hill (1986) reported observed glochidial infection from early spring through summer, with peak infection occurring from April through July. Smith (1988), however, concluded that spawning takes place between late November and late January with glochidia being released between late December and January, which is congruent with later findings by Johnson and

Brown (1998). Several fish species have been suggested as potential host for the Louisiana pearlshell mussel, including the following species: striped shiner (Notropis chrysocephalus), redfin shiner (Lythrurus umbratilis), golden shiner (Notemigonus crysoleucas), brown madtom (Notorus phaeus), and the black spotted topminnow (Fundulus olivaceus) (Hill 1986, Johnson and Brown 1998, Coldiron 2007). However, all reports of potential host fish were made from observing glochidia attached on the gills of wild caught fish, with none confirmed from observation of metamorphosis of glochidia (embryos) into juveniles. No information currently exists regarding sex ratio, juvenile recruitment, or mortality rate for the Louisiana pearlshell mussel. Johnson and Brown (1998) estimated the maximum lifespan of this species to vary between 45 and 75 years (USFWS 2011).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2011)

Environmental Specificity

Adult: Very narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe 2015)

Site Fidelity

Adult: High (see dispersal migration narrative)

Habitat Narrative

Adult: Louisiana pearlshell mussels require clear, moderately swift-flowing, perennial streams having stable mineral substrate, such as sandy bottom with rocky outcroppings. They often occur in shallow (water 12 to 24 inches deep) (Johnson 1995), wide areas, with well-compacted substrate, or infrequent patches of larger gravel substrate and are rarely found in deep pools that have slower flowing water and silty bottoms (Johnson and Brown 2000) (USFWS 2011). The environmental specificity of this species is very narrow, as it only occurs in soft water oligotrophic small creeks in a small area in Louisiana and is highly intolerant of adverse impacts from poor water quality (USFWS, 1989k). Separation barriers within standing water bodies are based solely on separation distance. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Mom-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: This species probably is rather sessile with only limited movement in the substrate. Passive downstream movement may occur when mussels are displaced from the substrate during floods. Major dispersal occurs while glochidia are encysted on their hosts (NatureServe 2015).

Population Information and Trends

Population Trends:

80% decline (NatureServe 2015)

Species Trends:

Uncertain (USFWS 2011)

Resiliency:

Current Resilience, Redundancy, and Representation: There are currently five Louisiana pearlshell populations with high resilience, three with moderate resilience, and one with low resilience (Table 12, Figure 13; See Appendix C for more detailed table of how resilience factors were scored). Additionally, there are four known extirpated populations (i.e., historically supported aggregations and now do not, though they might still support low numbers of scattered mussels), and two locations that are not considered to be populations (i.e., historically supported low numbers of mussels, never supported aggregations in survey history, though they might still support low numbers of scattered mussels). Of the five populations with high resilience, all had aggregation scores in good condition (greater than 10), and the one population with low resilience had a poor aggregation score. However, aggregation scores alone did not determine population resilience. Of the three populations with moderate resilience, two (Castor Creek and Brown Creek) had poor aggregation scores, but showed evidence of reproduction and had favorable habitat conditions, giving them the same resilience classification as a population (Valentine Creek) that had a moderate aggregation score but poor substrate score (USFWS, 2019).

Representation:

Current Resilience, Redundancy, and Representation: There are currently five Louisiana pearlshell populations with high resilience, three with moderate resilience, and one with low resilience (Table 12, Figure 13; See Appendix C for more detailed table of how resilience factors were scored). Additionally, there are four known extirpated populations (i.e., historically supported aggregations and now do not, though they might still support low numbers of scattered mussels), and two locations that are not considered to be populations (i.e., historically supported low numbers of mussels, never supported aggregations in survey history, though they might still support low numbers of scattered mussels). Of the five populations with high resilience, all had aggregation scores in good condition (greater than 10), and the one population with low resilience had a poor aggregation score. However, aggregation scores alone did not determine population resilience. Of the three populations with moderate resilience, two (Castor Creek and Brown Creek) had poor aggregation scores, but showed evidence of reproduction and had favorable habitat conditions, giving them the same resilience classification as a population (Valentine Creek) that had a moderate aggregation score but poor substrate score (USFWS, 2019).

Redundancy:

Current Resilience, Redundancy, and Representation: There are currently five Louisiana pearlshell populations with high resilience, three with moderate resilience, and one with low resilience (Table 12, Figure 13; See Appendix C for more detailed table of how resilience factors were scored). Additionally, there are four known extirpated populations (i.e., historically supported aggregations and now do not, though they might still support low numbers of scattered mussels), and two locations that are not considered to be populations (i.e., historically supported low numbers of mussels, never supported aggregations in survey history, though they might still support low numbers of scattered mussels). Of the five populations with high resilience, all had aggregation scores in good condition (greater than 10), and the one population with low resilience had a poor aggregation score. However, aggregation scores alone did not determine population resilience. Of the three populations with moderate resilience, two (Castor Creek and Brown Creek) had poor aggregation scores, but showed evidence of reproduction and had favorable habitat conditions, giving them the same resilience classification as a population (Valentine Creek) that had a moderate aggregation score but poor substrate score (USFWS, 2019).

Number of Populations:

9 (USFWS, 2022)

Population Size:

2,500 - 10,000 (NatureServe 2015)

Population Narrative:

The status of this species is uncertain based on the 2010 Recovery Data Call. (USFWS 2011). This species is restricted to only two river drainages (about 20 occurrences) in central Louisiana, having declined by over 80% in only a few generations time for this long-lived species. The range extent is 40 - 100 square miles, with an estimated population size of 2,500 - 10,000 individuals. 1 - 3 of the known occurrences have good viability/integrity (NatureServe 2015). The following presents the current condition of the Louisiana pearlshell, which is described in terms of “resilience”, “redundancy” and “representation” as it is found in the Louisiana pearlshell species status assessment (Service 2019a). Resilience is the ability of populations to sustain under different favorable and unfavorable conditions. There are currently five Louisiana pearlshell populations with high resilience, three with moderate resilience, and one with low resilience (SSA Service 2019a). Additionally, there are four known extirpated populations (i.e., historically supported aggregations and now do not, although they might still support low numbers of scattered mussels), and two locations that are not considered to be populations (i.e., historically supported low numbers of mussels, but never supported aggregations in survey history, although they might still support low numbers of scattered mussels). Redundancy refers to having multiple populations which allows species to withstand catastrophic impacts to any one population by spreading risk across the species’ range. Random catastrophic events that could severely impact entire populations include, but are not limited to, the drying of streams during drought, and upstream and downstream impacts from beaver dams, as well as potential direct mortality at dam sites. Representation refers to the breadth of genetic and environmental diversity within and among populations that contribute to the ability of the species to respond and adapt to changing environmental conditions over time. Units of representation for the Louisiana pearlshell are four management units, Black Creek, Bayou Boeuf, Bayou Rapides, and Bayou Rigolette. There is a moderate degree of redundancy and representation across the Louisiana pearlshell range, given that the Louisiana pearlshell is an endemic species with a historically limited range. Only one population (Black Creek, highly resilient) occurs in the Black Creek management watershed north of the Red River, but there is no evidence to suggest that any additional populations ever existed there. Though it is highly resilient, the extent of pearlshell aggregations within the population has declined, particularly in Beaver Creek and certain segments of Black Creek. There is also just a single population (Brown Creek, moderately resilient) in the Bayou Rapides management watershed (south of the Red River), which contains only four small Louisiana pearlshell aggregations. The Brown Creek population extent has contracted, where aggregations are not found as far upstream as they once were (USFWS, 2022).

Threats and Stressors

Stressor: Impoundments (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: Reservoirs, lakes, and other impoundments continue to fragment the spatial distribution of Louisiana pearlshell mussel habitat on the landscape, just as they have done from the time of initial listing. Beaver activity has also been documented as a source disruption to species' distribution throughout the range since the beginning of the species' monitoring and survey efforts. Beaver dams create impoundments within Louisiana pearlshell mussel watersheds, thus having the potential to significantly alter hydrology and affect the spatial distribution of the Louisiana pearlshell mussel throughout its range (USFWS 2011).

Stressor: Forestry (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: Forestry practices that provide for the harvesting of trees up to the stream line can decrease bank stability, cause direct soil erosion into the stream, and increase runoff with resultant increases in water turbidity and scouring of the stream bed; all of which can create unsuitable or unstable habitat for mussels. In addition, streams that lose trees in the riparian areas suffer a loss in the ability to naturally filter out the sediment and debris that was once captured by the vegetated riparian buffer. Furthermore, when trees are removed from alongside streams, the more open areas are more visible and provide easier access to the channel for humans and animals. Finally, although not having yet been addressed in the literature as a current threat to Louisiana pearlshell mussel streams, the extensive loss of trees from the riparian area along a particular stream exposes more of the surface water to direct sunlight and could potentially lead to an increase in algal blooms and increase in water temperature over time (USFWS 2011)

Stressor: Erosion (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: Construction and other soil disturbing activities with inadequate erosion control measures (i.e., bridge replacement, road construction, culvert installation, road maintenance, utility right-of-ways, etc.) within Louisiana pearlshell mussel watersheds can also cause a direct loss of habitat or cause a reduction of habitat quality through project-related water quality 15 degradation (e.g., increased erosion, increased run-off, increased sediment loading and turbidity, decreased flow and dissolved oxygen, etc.) and changes in stream geomorphology (e.g., headcutting, bank sloughing, perched water tables, etc.). Potential impacts of insufficient erosion control can result from project-related soil disturbance during excavation, vegetation removal, etc., as well as from erosion occurring after construction is complete. Populations have been impacted from gravel mining on private lands and from erosion where clear cuts extended to the bank of streams. Clear cuts extending to the stream bank can increase runoff with resultant scouring of the stream bed that creates unstable habitat for mussels (58 FR 49936) (USFWS 2011).

Stressor: ATV use (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: Activities, such as recreational use of all-terrain vehicles in Louisiana pearlshell mussel watershed habitat can decrease bank stability and lead to gully formation and heavy silt loading into the stream, thereby reducing in-stream water quality. An additional threat exists from direct mortality by crushing if those vehicles cross the stream at the location of Louisiana pearlshell mussel beds (LNHP 2009) (USFWS 2011).

Stressor: Isolated populations (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: Genetic research indicates that some Louisiana pearlshell mussels streams are isolated from each other (i.e., on each side of the Red River and upstream of Lake Iatt). Continued isolation of Louisiana pearlshell mussel streams could result in increased risks of genetic bottlenecks and inbreeding depression (Roe 2009), possibly resulting in reduced reproductive output and reduced viability of the mussel population within the isolated stream (USFWS 2011).

Stressor: Asiatic clam (USFWS 2011)
Exposure:
Response:
Consequence:
Narrative: The LNHP 2009 survey documented the presence of Asiatic clams (Corbicula fluminea) in every stream surveyed on private property. According to a DNR fact sheet on Aquatic Invasive species (found at http://www.in.gov/dnr/files/Asiatic_Clam.pdf), the Asiatic clam prefers similar habitat to that occupied by the Louisiana pearlshell mussel and can reach densities of 10,000 to 20,000 clams per square meter in a very short time. The possibility of Asiatic clams out-

competing the Louisiana pearlshell mussel may be a concern in the future, but cannot be accurately assessed at this time due to a deficiency of available data (USFWS 2011).

Recovery

Reclassification Criteria:
Recovery Priority Number: 8

Delisting Criteria:
1. At least six (6) populations exhibit a stable or increasing trend, as evidenced by natural recruitment and multiple age classes (Factors A and E) (USFWS 2022).

2. At least one population (as defined in Criteria 1) occurs in each of the following management watersheds Bayou Boeuf, Bayou Rapides, Bayou Rigolette, and Black Bayou (Factors A and E) (USFWS 2022).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A and E) (USFWS 2022).

Recovery Actions:
- Protect the known populations and their habitat (USFWS 1989).
- Conduct life history research (USFWS 1989).
- Determine the feasibility of reintroductions (USFWS 1989).
- Monitor population trends (USFWS 1989).
- Statistically analyze available data to estimate long-term population trend (USFWS 2011).
- Revise the recovery plan to address the Bayou Rigolette drainage populations, the current known threats to the species, current recovery actions needed, to incorporate new studies and data, and to identify delisting criteria (USFWS 2011).
- Develop a plan to implement in the case of a range-wide drought (USFWS 2011).
- Develop a scientifically based system of monitoring/surveying Louisiana pearlshell mussel populations to develop trends and identify any new populations or extirpated populations (USFWS 2011).
- Conduct life history research (i.e., determine host fish, water quality requirements/parameters, etc.) (USFWS 2011).
- Determine the habitat requirements, threats, and status of suitable host fish when it is identified (USFWS 2011).
- Continue beaver control activities (USFWS 2011).
- Determine the age structure of extant populations, the rate of juvenile recruitment, and population viability (USFWS 2011).
- Conduct long-term monitoring to determine if processes indicative of a “metapopulation” structure are occurring; i.e., what are rates of population extinction and colonization/recolonization, using genetic techniques to document source pools in colonization/recolonization events (USFWS 2011).
- Identify areas of suitable habitat within the historic range that are not currently occupied by the species, and determine if augmentation and expansion of the range is necessary to ensure viability. If feasible, develop propagation and augmentation technology/techniques (USFWS 2011).

- Monitor invasive Asiatic clams in Louisiana pearlshell mussel watersheds. Investigate the need for and, if necessary, develop methodologies for control of the invasive species (USFWS 2011).
- RECOMMENDATIONS FOR FUTURE ACTIONS: • Statistically analyze available data to estimate long-term population trend. ■ Revise the recovery plan to address the Bayou Rigolette drainage populations, the current known threats to the species, current recovery actions needed, to incorporate new studies and data, and to identify delisting criteria. • Develop a plan to implement in the case of a range-wide drought. • Develop a scientifically based system of monitoring/surveying Louisiana pearlshell mussel populations to develop trends and identify any new populations or extirpated populations. • Conduct life history research (i.e., determine host fish, water quality requirements/parameters, etc.). • Determine the habitat requirements, threats, and status of suitable host fish when it is identified. ■ Continue beaver control activities. • Determine the age structure of extant populations, the rate of juvenile recruitment, and population viability. • Conduct long-term monitoring to determine if processes indicative of a "meta population" structure are occurring; i.e., what are rates of population extinction and colonization/recolonization, using genetic techniques to document source pools in colonization/recolonization events. • Identify areas of suitable habitat within the historic range that are not currently occupied by the species, and determine if augmentation and expansion of the range is necessary to ensure viability. If feasible, develop propagation and augmentation technology/techniques. • Monitor invasive Asiatic clams in Louisiana pearlshell mussel watersheds. Investigate the need for and, if necessary, develop methodologies for control of the invasive species (USFWS, 2017).

Conservation Measures and Best Management Practices:

- USFWS. 2022. Louisiana Pearlshell (Margaritifera hembeli) Status Review: Summary and Evaluation. Southeast Region. Louisiana Ecological Services Office. Lafayette, Louisiana. 16 pp.

References

USFWS 2011. Louisiana Pearlshell Mussel (Margaritifera hembeli) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Louisiana Ecological Services Office Lafayette, Louisiana

U.S. Fish and Wildlife Service. 1989. Louisiana Pearlshell (Margaritifera hembeli) Recovery Plan. U.S. Fish and Wildlife Service. Jackson, Mississippi. 15 pp.

U.S. Fish and Wildlife Service. 1989. Louisiana Pearlshell (Margaritifera hembeli) Recovery Plan. U.S. Fish and Wildlife Service. Jackson, Mississippi. 15 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 1, 2016).

USFWS. 2019. Louisiana Pearlshell (Magaritifera hembeli). Species Status Assessment. Version 1.0. U.S. Fish and Wildlife Service. Region 4. Atlanta, GA. Louisiana Ecological Services Office. Lafayette, LA. USFWS. 2022. Louisiana Pearlshell (Margaritifera hembeli) Status Review: Summary and

Evaluation. Southeast Region. Louisiana Ecological Services Office. Lafayette, Louisiana. 16 pp.

USFWS. 2011. Louisiana Pearlshell Mussel (Margaritifera hembeli) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Louisiana Ecological Services Office Lafayette, Louisiana.

USFWS 2011. Louisiana Pearlshell Mussel (Margaritifera hembeli) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Louisiana Ecological Services Office Lafayette, Louisiana.

USFWS. 2017. Louisiana Pearlshell Mussel (Margaritifera hembeli). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. Southeast Region. Louisiana Ecological Services Office. Lafayette, Louisiana. 15 pp.

USFWS. 2022. Louisiana Pearlshell (Margaritifera hembeli) Status Review: Summary and Evaluation. Southeast Region. Louisiana Ecological Services Office. Lafayette, Louisiana. 16 pp.

RECOMMENDED FUTURE ACTIVITIES This 5-year review does not identify new recovery activities, research, monitoring, or data analysis needs because the Revised Recovery Plan (Service 2019b) and the SSA report (Service 2019a) are recent and up to date documents that present the best science currently available and identify current and potential conservation, research, and monitoring activities necessary for Louisiana pearlshell recovery. A detailed discussion of recovery actions, recovery criteria, current research and monitoring, and future research and monitoring needs are presented in the Revised Recovery Plan (Service 2019b) and the SSA (Service 2019a) (USFWS< 2022).

SPECIES ACCOUNT: *Margaritifera marrianae* (Alabama pearlshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/10/2012; Southeast Region (R4) (USFWS, 2016)

Physical Description

The pearlshell is oblong and grows up to 95 millimeters (mm) (3.8 inches (in)) in length. The outside of the shell (periostracum) is smooth and shiny and somewhat roughened along the posterior slope. The inside of the shell (nacre) is whitish or purplish and moderately iridescent (refer to Johnson 1983 for a full description) (USFWS 2012).

Taxonomy

The Alabama pearlshell is one of five North American species in the family Margaritiferidae. The family is represented by only two genera, Margaritifera (Schumacher 1816) and Cumberlandia (Ortmann 1912). In Alabama, each genus is represented by a single species—the spectaclecase (Cumberlandia monodonta) occurs in the Tennessee River Basin (Williams et al. 2008, pp. 94–95), and the Alabama pearlshell occurs in the Escambia and Alabama river basins in south Alabama (USFWS 2012).

Historical Range

Historically, the Alabama pearlshell occurred in portions of the Escambia River drainage, and has also been reported from two systems in the Alabama River drainage (USFWS 2012).

Current Range

Extant populations occur in Big Flat Creek (Monroe county, AL); Amos Mill Creek (Conecuh, Escambia county, AL); Bottle Creek (Conecuh county, AL); Burnt Corn Creek (Conecuh county, AL); Little Cedar Creek (Conecuh county, AL); Otter Creek (Conecuh county, AL); Sandy Creek (Conecuh county, AL) (USFWS 2012).

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On October 10, 2012, the U.S. Fish and Wildlife Service, determined endangered species status for the Alabama pearlshell (Margaritifera marrianae), under the Endangered Species Act of 1973, as amended (Act); and designated critical habitat for this species.

Critical Habitat Designation

The critical habitat designation for Margaritifera marrianae includes two units totaling 153 miles of stream length in Monroe, Wilcox, Escambia and Conecuh Counties, Alabama. The units are AP1: Big Flat Creek and AP2: Burnt Corn Creek, Murder Creek, and Sepulga River.

Unit AP1: Big Flat Creek Drainage, Alabama. Unit AP1 encompasses 92 km (57 mi) of the Big Flat Creek drainage, in Monroe and Wilcox Counties, AL. The unit is within the Mobile River basin. It includes the mainstem of Big Flat Creek from State Route 41 upstream 56 km (35 mi), Monroe County, AL; Flat Creek from its confluence with Big Flat Creek upstream 20 km (12 mi), Monroe County, AL; and Dailey Creek from its confluence with Flat Creek upstream 17 km (11 mi), Wilcox

County, AL. Unit AP1 is within the geographical area occupied at the time of listing (2012) for the Alabama pearlshell. Based on collection records, the species was last collected in the Big Flat Creek system in 1995, when Shelton (1995, p. 3 unpub. report) documented a fresh dead individual. Although it is likely that the Alabama pearlshell has always been rare in Big Flat Creek, the unit currently supports healthy populations of several other native mussel species, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. A diverse fish fauna, including potential fish host(s) for the Alabama pearlshell, are known from the Big Flat Creek drainage, indicating the potential presence of PCE 5. Threats to the Alabama pearlshell and its habitat may require special management of the physical or biological features including maintaining natural stream flows and protecting water quality from excessive point- and non-point-source pollution. For example, runoff from agricultural and industrial sites can alter water quality through added nutrients and sediment. Runoff from unpaved roads can also add sediments, and poorly designed road culverts can degrade habitats and limit distribution of the species. Some culverts can isolate pearlshell populations by acting as a barrier for dispersion and movement of host fish(es).

Unit AP2: Burnt Corn Creek, Murder Creek, and Sepulga River Drainages, Alabama. Unit AP2 encompasses 155 km (96 mi) of the Burnt Corn Creek, Murder Creek, and Sepulga River drainages within the Escambia River drainage in Escambia and Conecuh Counties, AL. It includes the mainstem of Burnt Corn Creek from its confluence with Murder Creek upstream 66 km (41 mi), Conecuh County, AL; the mainstem of Murder Creek from its confluence with Jordan Creek upstream 17 km (11 mi) to the confluence of Otter Creek, Conecuh County, AL; Jordan Creek from its confluence with Murder Creek upstream 12 km (7 mi), Conecuh County, AL; Otter Creek from its confluence with Murder Creek upstream 9 km (5.5 mi), Conecuh County, AL; Hunter Creek from its confluence with Murder Creek upstream 4.4 km (2.7 mi) to the NOLF Evergreen northern boundary, Conecuh County, AL; Hunter Creek from the NOLF Evergreen southern boundary upstream 3.0 km (1.9 mi), Conecuh County, AL; Sandy Creek from County Road 29 upstream 5 km (3.5 mi) to Hagood Road; two unnamed tributaries to Sandy Creek—one from its confluence with Sandy Creek upstream 8.5 km (5.0 mi) to Hagood Road, and the other from its confluence with the previous unnamed tributary 2.5 km (1.5 mi) upstream to Hagood Road, Conecuh County, AL; Little Cedar Creek from County Road 6 upstream 8 km (5 mi), Conecuh County, AL; Amos Mill Creek from its confluence with the Sepulga River upstream 12 km (8 mi), Escambia and Conecuh Counties, AL; Polly Creek from its confluence with Amos Mill Creek upstream 3 km (2 mi), Conecuh County, AL; and Bottle Creek from its confluence with the Sepulga River upstream 5.5 km (3.5 mi) to County Road 42, Conecuh County, AL. Unit AP2 is mostly within the geographical area occupied at the time of listing (2012) for the Alabama pearlshell. The Alabama pearlshell currently occurs in Jordan, Hunter, Otter, Sandy, Little Cedar, Bottle, and Amos Mill creek drainages. Although it historically occurred in the mainstem of Murder Creek, it has not been collected there since 1991. Therefore, this short reach of Murder Creek is considered unoccupied by the Alabama pearlshell, but essential to the conservation of the species. This unoccupied reach retains the physical or biological features of a natural stream channel and supports other native mussel species. It has potential for reoccupation by the pearlshell, particularly if threats can be identified and mitigated. The unit currently supports healthy populations of several other native mussel species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with the pearlshell. A diverse fish fauna, including potential fish host(s) for the Alabama pearlshell, are known from these drainages, indicating the potential presence of PCE 5. Threats to the Alabama pearlshell and its habitat that may require special management of the physical or biological featues include alteration and maintenance of natural stream flows (including the construction of impoundments), and protecting water quality from excessive point- and nonpoint-source pollution.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Alabama pearlshell consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to the species and its habitat are pervasive and common in all of the units that are designated as critical habitat. These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas designated as critical habitat are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Adult: Freshwater mussels, such as this species, filter algae, detritus, and bacteria from the water column (Williams et al. 2008, p. 67). For the first several months, juvenile mussels employ pedal (foot) feeding, extracting bacteria, algae, and detritus from the sediment (Yeager et al. 1994, pp. 217– 221) (USFWS 2012).

Reproduction Narrative

Adult: The species is believed to be a long-term brooder, where gravid females have been observed in December. The host fish and other aspects of its life history are currently unknown (USFWS 2012).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (USFWS 2012)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: The Alabama pearlshell typically inhabits small headwater streams with mixed sand and gravel substrates, occasionally in sandy mud, with slow to moderate current. The habitat is linear in nature. Primary constituent elements include geomorphically stable stream and river channels and banks; stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment; a hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats; water quality, including temperature (not greater than 32 oC), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 mg/L), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages (USFWS 2012). The environmental specificity of this species is narrow, as it is sensitive to pollution, siltation, habitat perturbation, inundation, and loss of glochidial hosts. Separation barriers within standing water bodies are based solely on separation distance (see Separation Distance-suitable, below). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

> 90% decline (NatureServe 2015)

Number of Populations:

9 extant (USFWS, 2023))

Population Size:

250 - 2,500 (NatureServe 2015)

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

It is unknown if this species are currently experiencing a loss of genetic diversity (USFWS 2012). The range extent of this species is 40 - 100 square miles, with a population size of 250 - 2,500 individuals. Only two of the four extant populations show evidence of recruitment. This species has declined by > 90%. In the 2012 listing rule, the Service identified 16 populations of Alabama pearlshell and classified seven populations as historical and nine as occupied. Since survey efforts have not documented presence of the species in the Alabama River basin since 1995, we believe the Alabama pearlshell is most likely extirpated from the basin, which includes the loss of the Big Flat Creek population. In the Conecuh/Escambia River basin, Bottle Creek may be an extirpated population due to its lack of recorded individuals since 1999. However, three relic shells were collected from Ard Creek, a tributary to Bottle Creek that is considered part of the

Bottle Creek population, in 2021 which may indicate continued presence of Alabama pearlshell downstream in Bottle Creek. A relic shell was collected in Horse Creek in the Conecuh/Escambia River basin in 2019, which indicates presence of Alabama pearlshell in this system. As of this review, seven populations are considered extirpated, and nine are considered current or likely to have live individuals still present. The status of three current populations, including Bottle, Burnt Corn, and Horse creeks, is based solely on records of weathered dead or relic shells. The status of the remaining current populations was based on records of live individual records; however, most surveys or observations recorded less than 10 live individuals. Surveys of Jordan, Little Cedar, and Sandy creeks have documented higher numbers of adults and presence of gravid females which indicate that these populations may be the largest and most stable (USFWS, 2023).

Threats and Stressors

Stressor: Pollution (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Nonpoint-source pollution from land surface runoff originates from virtually all land use activities and includes sediments, fertilizer, herbicide and pesticide residues; animal wastes; septic tank leakage and gray water discharge; and oils and greases. Land surface runoff also contributes nutrients (for example, nitrogen and phosphorus from fertilizers, sewage, and animal manure) to rivers and streams, causing them to become eutrophic. Excessive nutrient input stimulates excessive plant growth (algae, periphyton attached algae, and nuisance plants). This enhanced plant growth can cause dense mats of filamentous algae that can expose juvenile mussels to entrainment or predation and be detrimental to the survival of juvenile mussels (Hartfield and Hartfield 1996, p. 373). Excessive plant growth can also reduce dissolved oxygen in the water when dead plant material decomposes (USFWS 2012).

Stressor: Land use activities (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Current activities and land uses that can negatively affect populations of these eight mussels include unpaved road crossings, improper silviculture and agriculture practices, highway construction, housing developments, pipeline crossings, and cattle grazing. These activities can result in physical disturbance of stream substrates or the riparian zone, excess sedimentation and nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and altered flow. Activities such sand and gravel mining, the removal of large woody material, off-road vehicles use, and land use changes are known to cause channel destabilization. Activities that destabilize stream beds and channels can result in drastic alterations to stream geomorphology and consequently to the stream’s ecosystem (USFWS 2012).

Stressor: Sedimentation (USFWS 2012)
Exposure:
Response:
Consequence:

Narrative: Sedimentation is one of the most significant pollution problems for aquatic organisms (Williams and Butler 1994, p. 55), and has been determined to be a major factor in mussel declines (Ellis 1936, pp. 39–40). Impacts resulting from sediments have been noted for many components of aquatic communities. For example, sediments have been shown to abrade or suffocate periphyton (organisms attached to underwater surfaces); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters 1995, pp. 173– 175). When in high silt environments, mussels may keep their valves closed more often, resulting in reduced feeding activity (Ellis 1936, p. 30), and high amounts of suspended sediments can dilute their food source (Dennis 1984, p. 212). Increased turbidity from suspended sediment can reduce or eliminate juvenile mussel recruitment (Negus 1966, p. 525; Brim Box and Mossa 1999, pp. 101–102). Many mussel species use visual cues to attract host fishes; such a reproductive strategy depends on clear water (USFWS 2012).

Stressor: Impoundments (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The damming of rivers has been a major factor contributing to the demise of freshwater mussels (Bogan 1993, p. 604). Dams eliminate or reduce river flow within impounded areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, affect normal flood patterns, and block upstream and downstream movement of mussels and their host fishes (Bogan 1993, p. 604; Vaughn and Taylor 1999, pp. 915–917; Watters 1999, pp. 261–264; McAllister et al. 2000, p. iii; Marcinek et al. 2005, pp. 20–21). Downstream of dams, mollusk declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels, water temperatures, and changes in resident fish assemblages (Williams et al. 1993, p. 7; Neves et al. 1997, pp. 63–64; Watters 1999, pp. 261– 264; Marcinek et al. 2005, pp. 20–21) (USFWS 2012).

Stressor: Stochastic events (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may contribute to the further decline of mussel populations suffering the effects of other threats. During high flows, flood scour can dislodge mussels where they may be injured, buried, or swept into unsuitable habitats, or mussels may be stranded and perish when flood waters recede (Vannote and Minshall 1982, p. 4105; Tucker 1996, p. 435; Hastie et al. 2001, pp. 107–115; Peterson et al. 2011, unpaginated). Heavy spring rains in 2009 resulted in severe flooding in the basins that destroyed numerous stream crossings. During drought, stream channels may become disconnected pools where mussels are exposed to higher water temperatures, lower dissolved oxygen levels, and predators, or channels may become dewatered entirely (USFWS 2012).

Stressor: Small, isolated populations (USFWS 2012)
Exposure:
Response:

Consequence:
Narrative: Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153) (USFWS 2012).

Stressor: Asian clam (USFWS 2012)
Exposure:
Response:
Consequence:
Narrative: The Asian clam (Corbicula fluminea) has been introduced to the drainages and may be adversely affecting these eight mussels through direct competition for space and resources. The invasion of the Asian clam in these and in other eastern Gulf drainages has been accompanied by drastic declines in populations of native mussels (see observations by Heard 1975, p. 2; and Shelton 1995, p. 4 unpub. report). The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations. The flathead catfish is a large predator native to the central United States, and since its introduction outside its native range, it has altered the composition of native fish populations through predation (Boschung and Mayden 2004, p. 350) (USFWS 2012).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 5

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.
- Not available

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIVITIES Because we have no final approved final Recovery Plan for the species, we provide the activities indicated below as activities to inform and improve the species recovery. • Develop a captive propagation plan for the species. o Continue to develop and refine propagation techniques for future augmentation and reintroduction. o Continue to investigate potential sites for reintroduction of captive reared individuals. • Conduct quantitative surveys within known occupied areas and continue surveys in other areas to find additional populations. • Conduct formal toxicity testing to understand sensitivity of Alabama pearlshell to pollution threats in these systems. • Continue to develop partnerships and conservation initiatives with landowners within the range of the Alabama pearlshell in the Alabama and Conecuh/Escambia basins. • Restore and improve conditions of Alabama pearlshell habitat through activities such as bank stabilization, riparian buffer maintenance/augmentation, adherence to BMPs, and other

conservation efforts (USFWS, 2023).

References

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. Pages 61663 - 61719.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 FR 61663 - 61719 (October 10, 2012).

Final Rule. 77 Federal Register 196. Pages 61663 - 61719

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 1, 2016). USFWS. 2023. Alabama pearlshell (Margaritifera marrianae) 5-Year Review: Summary and Evaluation. Southeast Region. Alabama Ecological Services Field. Office Daphne, Alabama. 30 pp.

Determination ofEndangered Species Status for the Alabama Pearlshell, Round Ebonyshell,Southern Kidneyshell, and Choctaw Bean, and Threatened Species Statusfor the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and FuzzyPigtoe, and Designation of Critical Habitat

USFWS. 2012. Endangered and Threatened Wildlife and Plants

USFWS. 2023. Alabama pearlshell (Margaritifera marrianae) 5-Year Review: Summary and Evaluation. Southeast Region. Alabama Ecological Services Field. Office Daphne, Alabama. 30 pp.

SPECIES ACCOUNT: *Medionidus acutissimus* (Alabama moccasinshell)

Species Taxonomic and Listing Information

Listing Status: Threatened; March 17, 1993; Southeast Region (R4) (USFWS 2008)

Physical Description

A small, delicate species, approximately 30 mm (1.2 in) in length. Shell is narrowly elliptical (oval), with a well-developed, acute posterior ridge that terminates in a sharp point on the posterior ventral margin. The posterior slope is finely corrugated. The periostracum (outer surface) is yellow to brownish yellow, with broken green rays across the entire surface of the shell. The nacre (inner surface) is thin and translucent along the margins and salmon-colored in the umbos (beak cavity) (USFWS 2008).

Taxonomy

Simpson (1914) and Ortmann (1924) recognized Medionidus parvulus as distinct from Medionidus acutisssimus. Van der Schalie (1938) noted that they integrated. Johnson (1977) synonymized M. parvulus with M. acutissimus. Genetic analysis is needed to determine the proper identification of some populations (e.g., Medionidus specimens from the Conasauga River). The relationship of Medionidus acutissimus to Medionidus parvulus is unclear as the two overlap in shell morphology in parts of their ranges. Further taxonomic questions exist as to the relationship between Mobile Basin M. acutissimus and what appears to be that species in the Choctawhatchee, Yellow, and Escambia drainages as slight conchological differences exist. M. acutissimus from the Escambia, Yellow, and Choctawhatchee River drainages are also similar morphologically to Medionidus penicillatus and some authors have included those populations in the range of M. penicillatus(Johnson, 1977; Butler, 1990; Williams and Butler, 1994), but those populations are included in the range of M. acutissimus by Williams et al. (2008) because faunal distribution patterns suggest that faunas in the Choctawhatchee, Yellow, and Escambia River drainages are more closely related to those of the Mobile Basin than those of the Apalachicola Basin (NatureServe 2015).

Historical Range

It is historically known to occur in the Alabama River and tributaries, Alabama; Tombigbee River and tributaries, Mississippi, Alabama; Black Warrior River and tributaries, Alabama; Cahaba River, Alabama; Coosa River and tributaries, Alabama, Georgia, Tennessee (USFWS 2000).

Current Range

The species is currently known to survive in 7 drainages of the Mobile River Basin. There are 12 tributary populations, including Bull Mountain Creek (Itawamba county, MS), Luxapalila Creek (Lowndes county, MS), Yellow Creek (Lowndes county MS; Lamar county, AL), Buttahatchee River (Lowndes/Monroe county, MS; Lamar county, AL), Sipsey Creek (Monroe county, MS), Lubbub Creek (Pickens county, AL), Sipsey River (Greene/Pickens county, AL), Black Warrior River and tributaries (Winston/Lawrence county, AL), Holly Creek (Murray county, GA) (Dodd et al. 1986, Evans 2001, Hartfield and Bowker 1992, Hartfield and Jones 1989, 1990, Johnson and Evans 2000, Jones 1991, Jones and Majure 1999, McGregor 1992, McGregor et al. 1996, McGregor 2000, McGregor et al. 2000, McGregor and Haag 2004, MS Museum of Natural Science collection record 1984 - 2001, Pierson 1991a, b, Warren and Haag 1994, Yokely 2001) (USFWS 2008).

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the Alabama moccasinshell, under the Endangered Species Act of 1973, as amended (Act).

Critical Habitat Designation

Critical habitat for the Alabama moccasinshell (Medionidus acutissimus) is designated in Units 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 25, 26; in AL, GA, MS, and TN.

Unit 1. East Fork Tombigbee River, Monroe, Itawamba Counties, Mississippi. Unit 1 encompasses 26 km (16 mi) of the East Fork Tombigbee River channel in Mississippi extending from Mississippi Highway 278, Monroe County, upstream to the confluence of Mill Creek, Itawamba County, Mississippi. This reach of the East Fork Tombigbee River continues to support the southern clubshell and orange-nacre mucket (Hartfield and Jones, 1989; Miller and Hartfield, 1988; Mississippi Museum of Natural Science (MMNS) mussel collections, 1984–2001). This unit is within the historic range of the Alabama moccasinshell and ovate clubshell.

Unit 2. Bull Mountain Creek, Itawamba County, Mississippi. Unit 2 encompasses 34 km (21 mi) of the Bull Mountain Creek stream channel in Mississippi extending from Mississippi Highway 25, upstream to U.S. Highway 78, Itawamba County, Mississippi. Bull Mountain Creek supports the southern clubshell and Alabama moccasinshell (Jones and Majure, 1999). This unit is within the historic range of the orange-nacre mucket (records are from the early 1980's (MMNS mussel collections)) and the ovate clubshell.

Unit 3. Buttahatchee River and tributary, Lowndes/Monroe County, Mississippi; Lamar County, Alabama. Unit 3 encompasses 110 km (68 mi) of river and stream channel in Mississippi and Alabama, including 87 km (54 mi) of the Buttahatchee River, extending from its confluence with the impounded waters of Columbus Lake (Tombigbee River), Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and 23 km (14 mi) of Sipsey Creek, extending from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi. The Buttahatchee River continues to support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 2001; Hartfield and Jones, 1989; Jones, 1991; McGregor, 2000). The current distribution of the Alabama moccasinshell also extends into its tributary Sipsey Creek (McGregor, 2000).

Unit 4. Luxapalila Creek and tributary, Lowndes County, Mississippi; Lamar County, Alabama. Unit 4 encompasses 29 km (18 mi) of stream channel, including 15 km (9 mi) of Luxapalila Creek, extending from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and 15 km (9 mi) of Yellow Creek extending from its confluence with Luxapalila Creek, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama. Luxapalila and Yellow Creeks support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Hartfield and Bowker, 1992; McGregor, 2000; Miller, 2000; Yokley 2001).

Unit 5. Coalfire Creek, Pickens County, Alabama. Unit 5 encompasses 32 km (20 mi) of the Coalfire Creek stream channel extending from its confluence with the impounded waters of Aliceville Lake (Tombigbee River), upstream to U.S. Highway 82, Pickens County, Alabama. Coalfire Creek supports the orange-nacre mucket and ovate clubshell (P. Hartfield, Service field records 1991; McGregor, 2000). The creek is in the historic range of the southern clubshell and Alabama moccasinshell.

Unit 6. Lubbub Creek, Pickens County, Alabama. Unit 6 encompasses 31 km (19 mi) of the Lubbub Creek stream channel extending from its confluence with the impounded waters of Gainesville Lake (Tombigbee River), upstream to the confluence of Little Lubbub Creek, Pickens County, Alabama. This stream supports the southern clubshell, orangenacre mucket, and Alabama moccasinshell (P. Hartfield, Service field records, 1991; McGregor, 2000; Pierson, 1991a). It is in the historic range of the ovate clubshell.

Unit 7. Sipsey River, Greene/Pickens, Tuscaloosa Counties, Alabama. Unit 7 encompasses 90 km (56 mi) of the Sipsey River channel from the confluence with the impounded waters of Gainesville Lake (Tombigbee River), Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama. This small river supports and provides some of the best remaining habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 1997; McCullagh et al., 2002; McGregor, 2000; MMNS Mussel Collection; Pierson, 1991 a, b).

Unit 8. Trussels Creek, Greene County, Alabama. Unit 8 encompasses 21 km (13 mi) of creek channel extending from its confluence with the impounded waters of Demopolis Lake (Tombigbee River), upstream to Alabama Highway 14, Greene County, Alabama. The orangenacre mucket continues to survive in Trussels Creek, and it is in the historic range of the ovate clubshell, Alabama moccasinshell, and southern clubshell (P. Hartfield field records, 1993; McGregor, 2000).

Unit 9. Sucarnoochee River, Sumter County, Alabama. Unit 9 encompasses 90 km (56 mi) of the Sucarnoochee River channel in Alabama, extending from its confluence with the Tombigbee River, upstream to the Mississippi/Alabama State Line, Sumter County, Alabama. The ovate clubshell continues to survive in the Sucarnoochee River (McGregor et al., 1996). The river is within the historic range of the southern clubshell, orangenacre mucket, and Alabama moccasinshell.

Unit 11. North River and tributary, Tuscaloosa, Fayette Counties, Alabama. Unit 11 encompasses 47 km (29 mi) of river and stream channel in Alabama, including: North River, 42 km (26 mi) extending from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; Clear Creek, 5 km (3 mi), from its confluence with North River, to Bays Lake Dam, Fayette County, Alabama. Small numbers of the dark pigtoe and orange-nacre mucket continue to survive in the North River and Clear Creek (McGregor and Pierson, 1999; Pierson, 1992a; Vittor and Associates, 1993). This area is in the historic range of the Alabama moccasinshell, triangular kidneyshell, and ovate clubshell.

Unit 12. Locust Fork and tributary, Jefferson, Blount Counties, Alabama. Unit 12 encompasses 102 km (63 mi) of river and stream channel in Alabama, including: Locust Fork, 94 km (58 mi) extending from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; Little Warrior River, 8 km (5 mi), from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama. Scattered collections of the orange-nacre mucket and triangular kidneyshell suggest an enduring population of these species in the Locust Fork (P. Johnson pers. comm., 2002; Hartfield, 1991; Shepard et al., 1988). This stream is also in the historic range of the dark pigtoe, Alabama moccasinshell, ovate clubshell, and upland combshell.

Unit 13. Cahaba River and tributary, Jefferson, Shelby, Bibb Counties, Alabama. Unit 13 encompasses 124 km (77 mi) of river channel in Alabama, including: Cahaba River, 105 km (65 mi) extending from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; Little Cahaba River, 19 km (12 mi), from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama. Scattered individuals of triangular kidneyshell, orange-nacre mucket, and fine-lined pocketbook continue to be collected from the Cahaba drainage (R. Haddock, Cahaba River Society, pers. comm., 2002; McGregor et al., 2000; Shepard et al., 1994). The river is historic habitat for the Alabama moccasinshell, southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 15. Bogue Chitto Creek, Dallas County, Alabama. Unit 15 encompasses 52 km (32 mi) of the Bogue Chitto Creek channel in Alabama, extending from its confluence with the Alabama River, Dallas County, upstream to U.S. Highway 80, Dallas County, Alabama. This stream continues to support the southern clubshell and orange-nacre mucket (McGregor et al., 1996; P. Hartfield field notes, 1984; Pierson, 1991a). The habitat offers potential for the Alabama moccasinshell.

Unit 25. Oostanaula River/Coosawattee River/Conasauga River/Holly Creek, Floyd, Gordon, Whitfield, Murray Counties, Georgia; Bradley, Polk Counties, Tennessee. Unit 25 encompasses 206 km (128 mi) of river and stream channel in Georgia and Tennessee, including: Oostanaula River, 77 km (48 mi) extending from its confluence with the Etowah River, Floyd County, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; Coosawattee River, 15 km (9 mi), from confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; Conasauga River, 98 km (61 mi), from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to the Murray County Road 2, Murray County, Georgia; Holly Creek, 16 km (10 mi), from confluence with Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia. This extensive riverine reach continues to support small and localized populations of fine-lined pocketbook, southern pigtoe, triangular kidneyshell, Alabama moccasinshell, and Coosa moccasinshell. The triangular kidneyshell survives throughout this unit, while the fine-lined pocketbook, southern pigtoe, and Coosa moccasinshell appear to be currently restricted to the Conasauga River and Holly Creek and the southern clubshell appears restricted to a small 15 km (9 mi) reach of the Conasauga River (Evans, 2001; Johnson and Evans, 2000; Pierson in litt., 1993; Williams and Hughes, 1998). The Alabama moccasinshell is currently known to survive only in the Holly Creek portion of this Unit (Evans, 2001; Johnson and Evans, 2000). The Oostanaula/ Coosawattee/Conasauga Unit also contains historic habitat for the southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 26. Lower Coosa River, Elmore County, Alabama. Unit 26 encompasses 13 km (8 mi) of the Lower Coosa River channel, extending from Alabama State Highway 111 bridge, upstream to

Jordan Dam, Elmore County, Alabama. This river reach is within the historic range of fine-lined pocketbook, southern clubshell, Alabama moccasinshell, Coosa moccasinshell, ovate clubshell, southern pigtoe, triangular kidneyshell, upland combshell, and southern acornshell. (Johnson, 2002; Pierson, 1991a).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the Alabama moccasinshell (Medionidus acutissimus) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: All mussels are filter feeders. Oxygen-bearing water and food are drawn into the incurrent siphon, and waste-carrying water is simultaneously passed out the excurrent siphon. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS 2000).

Reproduction Narrative

Adult: While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years (USFWS 2000). Females are gravid from October to June. Blackspotted topminnows (Fundulus olivaceus), Tuskaloosa darter (Etheostoma douglasi), redspot darter (E. artesiae), blackbanded darter (Percina nigrofaciata), naked sand darter (Ammocrypta beani), southern sand darter (A. meridiana), johnny darter (E. nigrum), speckled darter (E. stigmaeum), Gulf darter (E. swaini), saddleback darter (Percina vigil), and Mobile logperch (P. kathae) have been identified as suitable host fish (Haag and Warren, 1997, 2001; 2003b) (USFWS 2008). This species is a long term brooder (NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Fragmented (USFWS 2008)

Environmental Specificity

Adult: Narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits sand/gravel/cobble shoals with moderate to strong currents in streams and small rivers (USFWS 2000). This species lives completely embedded in stream bottoms for most of the year. The range is highly fragmented (USFWS 2008). The environmental specificity of this species is narrow, as it is tiny, inhabiting the interstices of gravel and cobble substrates, and is very sensitive to sedimentation and erosion (USFWS, 2000). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

50 - 70% decline (NatureServe 2015)

Species Trends:

Unknown (USFWS 2008)

Number of Populations:

12 (see current distribution)

Population Size:

2,500 - 10,000 (NatureServe 2015)

Adaptability:

Low (inferred from USFWS 2008)

Population Narrative:

The status of the species is unknown based on the 2007 Recovery Data Call. All monitored populations experienced significant declines in 2002, however some recruitment was observed. All populations are small, isolated, and vulnerable to stochastic events (USFWS 2008). The range extent of this species is 250 - 5,000 square miles with a population size of 2,500 - 10,000 individuals. The populations in the tributaries to the Sipsey Fork appear to be stable. Elsewhere, the status is believed to be declining. Overall, this species has declined by 50 - 70% (NatureServe 2015).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:

Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species. The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin. Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a mollusk-eating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Both the Conasauga River and Holly Creek are experiencing sediment and water quality problems, and Coosa mooccasinshell populations are susceptible to stochastic and chronic events (e.g., spills, drought and/or landuse runoff) (USFWS, 2008).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Stressor:
Exposure:
Response:

Consequence:
Narrative:

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:
This species has a final, approved recovery plan, however, recovery criteria were not specified because of the extent of decline, habitat loss and fragmentation, population isolation, and continuing impacts on their habitats (USFWS 2008).

Delisting Criteria:
1. Eight (8) populations exhibit a stable or increasing trend, natural recruitment, and multiple age classes (Factors A, D, and E). 2. Two (2) populations (as defined in Criterion 1) occur in each of the following sub basins: Tombigbee (2), Black Warrior (2), and Coosa rivers (2) (Factors A, D, and E). 3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A, D, and E) (USFWS, 2019).

Recovery Actions:
- Protect habitat integrity and quality (USFWS 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS 2000).
- Develop measurable recovery criteria (USFWS 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS 2008).
- Develop and implement plan to describe and monitor habitat conditions (USFWS 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife service Southeast Region Ecological Services. Jackson, Mississippi

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 4, 2016).

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 4, 2016)

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2019. Alabama Moccasinshell Amendment 1 to the U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Medionidus conradicus* (Cumberland moccasinshell)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

Attaining a maximum length of 60 mm (2.4 in), the Cumberland moccasinshell is elliptical shaped, slightly bowing or arching with age. Its shell is yellowish to tawny or brown and usually covered in green rays, and the posterior of the shell is usually marked with small ridges (USFWS, 2023).

Taxonomy

Medionidus conradicus, P. oviforme, and P. barnesiana belong to the family Unionidae, also known as the naiads or pearly mussels. North America contains the greatest diversity of freshwater mussels globally, comprising around 300 currently recognized species, with 29 species considered extinct and nearly 200 considered imperiled (Haag and Williams 2014, entire). This SSA follows the most recently published and accepted taxonomic treatment of North American freshwater mussels (Williams et al. 2017, entire). Recent studies have suggested potential genetic overlap between P. oviforme and the federally Endangered Pleurobema clava (Inoue et al. 2018, p. 698), and a potentially distinct form of P. oviforme may exist in the Little River in the upper Tennessee Basin (Schilling 2015, p. 105). Furthermore, the recovery plan and most recent 5-year review of P. clava acknowledges morphological and geographic overlap between P. clava and P. oviforme in the Tennessee and Cumberland River systems (Service 1994, p. 6; Service 2009, p. 11). Because no formal taxonomic changes have been published due to the limited data available, the present analysis treats P. oviforme as a valid species. Genetic analyses are ongoing (J. Jones and C. Morrison 2020, personal communication), and future assessments should carefully consider any taxonomic information published after the writing of this SSA report (USFWS, 2020).

Current Range

The Cumberland moccasinshell occurs in the Tennessee and Cumberland River drainages in Alabama, Georgia, Kentucky, Tennessee, and Virginia (see figure 3, below). It is presumed extirpated in North Carolina (USFWS, 2023).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Broadcast spawning

Lifespan

Adult: 10-23 years (USFWS, 2023)

Breeding Season

Adult: releases glochidia sporadically September through November, with peak releases occurring January through May (USFWS, 2023)

Key Resources Needed for Breeding

Adult: Host fish (Darters) (USFWS, 2023)

Other Reproductive Information

Adult: The Cumberland moccasinshell has a lifespan of approximately 10 years on average, with a maximum reported age of 24 years, based on shells from the Clinch River in Virginia and Tennessee (Scott 1994, pp. 16, 71). Age at maturity ranges from 1 to 3 years (Zale and Neves 1982, p. 19; T. Lane 2023, pers. comm.). Fish hosts include at least four (possibly six) species in the darter genus, Etheostoma (Service 2020, pp. 5–6). As a long-term brooder, the Cumberland moccasinshell spawns mid-July and releases glochidia sporadically September through November, with peak releases occurring January through May (USFWS, 2023)

Reproduction Narrative

Adult: Freshwater mussels, including the three species that are the subjects of this proposed rule, have a complex reproduction process involving parasitic larvae, called glochidia, that are wholly dependent on host fish. Mussels release sperm into the water column, which is taken in by the female, wherein fertilization and development of glochidia occurs in a restricted portion of the gills, called the brood pouch or marsupium. When mature, the glochidia are released to the water column to attach on the gills, head, or fins of fishes. Glochidia die if they fail to attach to a host fish, attach to an incompatible fish species, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 599). Once attached to the host, glochidia draw nutrients from the fish's tissue as they develop (Arey 1932, pp. 214–215). Time to development, from attachment of glochidia to maturation, ranges from just over 1 week to 6 weeks or more (Parmalee and Bogan 1998, p. 8). Depending on the species, mussels are either short-term or long-term brooders. In short-term brooders, fertilization occurs in the spring or summer and glochidia are released shortly after they are fully developed. In long-term brooders, fertilization occurs in late summer or fall, and developed glochidia are held over winter and released in the following spring or summer (Haag 2012, pp. 39–40). Mature glochidia drop off their hosts and, if they settle in suitable habitat on the stream bottom, continue the remainder of their existence as freeliving mussels. Newly released glochidia are juveniles that are reproductively immature but otherwise resemble adults, with both halves (valves) of the shell developed and poised for growth (USFWS, 2023)

Habitat Type

Adult: Aquatic

Habitat Narrative

Adult: Favoring strong currents, it is found in riffles and shoals of streams ranging from headwaters to medium-sized rivers amongst gravel, cobble, boulder, and occasionally sand and gravel substrates. It is sometimes found under large flat rocks or cracks in bedrock (USFWS, 2023).

Dispersal/Migration

Population Information and Trends

Species Trends:
Decreasing

Number of Populations:
Currently it occupies 34 to 63 watersheds, compared to 150 historically, reflecting a range reduction of 56 to 74 (USFWS, 2023)

Population Narrative:
The Cumberland moccasinshell historically occurred throughout the Tennessee and Cumberland River basins. Currently it occupies 34 to 63 watersheds, compared to 150 historically, reflecting a range reduction of 56 to 74 percent. Most extant populations of the species are classified as low condition (22), with nine populations classified as high condition and three populations classified as medium condition, indicating species condition is currently low (see table 3, above). With nine populations in high condition and two populations in medium condition in the Tennessee Basin, redundancy in the basin may buffer against stochastic events. However, these populations are concentrated in Upper Tennessee Basin tributaries, mainly the Clinch-Powell watershed, with seven high condition populations, and one high condition population in the Holston watershed. The Duck River watershed, in the lower Tennessee Basin, has one highcondition and two medium-condition populations. The low-condition populations in the rest of the Tennessee Basin lack resiliency and have little capacity to withstand effects of environmental stochasticity. Because there are no populations with high resiliency, and only one population with medium resiliency in the Cumberland basin ecological setting, and smaller-scale ecological settings outside the Upper Tennessee and Duck basins only contain populations with low resiliency, Cumberland moccasinshell representation, or its potential for adapting to environmental change, is diminished (USFWS, 2023).

Threats and Stressors

Stressor: Large Impoundments (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Our analysis identified large impoundments (indicated by reservoir surface area) as a rangewide threat to the three mussel species. The Tennessee Valley Authority operates 31 large dams in the Tennessee River system and one large dam (Great Falls Dam) in the Cumberland system (TVA Recreation Map website, 2023) and the U.S. Army Corps of Engineers operates 10 large dams in the Cumberland system (USACE Nashville District website, 2023). The effects of dams on aquatic habitats and freshwater mussels are well-documented (Watters 2000, p. 261), and extinction and extirpations of North American freshwater mussels can be traced to impoundment and inundation of riffle habitats in all major river basins of the central and eastern United States (Haag 2009, p. 107). Dams disrupt population connectivity and alter water quality. After a dam has been constructed, upstream the channel becomes deeper, flow decreases dramatically, and fine sediments accumulate on the channel bottom, which eliminates shoal and riffle habitats needed by the three mussel species, as well as many others, and their host fishes.

Downstream of dams, natural flow regimes are disrupted by alternating low flow releases and pulses of scouring flows (Hardison and Layzer 2001, p. 79), reduced water temperatures, reduced dissolved oxygen, and changes in fish assemblages. Mussels may survive in cold tailwaters but may not be able to reproduce, as was shown for native washboard mussels (Megalonaias nervosa) in the mainstem Cumberland River (Heinricher and Layzer 1999, entire). In a Cumberland River tributary, Caney Fork, the extirpation of several mussel species, including Cumberland moccasinshell, was attributed mainly to cold tailwater temperatures from Center Hill Dam (completed in 1948) and alteration of channel morphology from peaking flows, and no live mussels were found within 7.5 mi (12 km) of the dam outfall (Layzer et al. 1993, pp. 69–70) (USFWS, 2023).

Stressor: Developed Land Use/Urbanization (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: For all three mussel species, development and urbanization contribute to habitat degradation and loss. Freshwater mussel populations may experience reduced abundance, species richness, reproduction, growth, and survival stemming from the impacts of urbanization on water and habitat quality (Diamond and Serveiss 2001, p. 4716; Gangloff et al. 2009, p. 198; Cao et al. 2013, pp. 1212–1214; Gillis et al. 2017, pp. 674–679). The threats analysis in our SSA found the estimated probability of extirpation for all three species approaches 100 percent when developed land area is between 9 and 15 percent of the total land area in a watershed (Service 2020, p. 61). The term ‘‘development’’ refers to urbanization of the landscape, including (but not limited to) land conversion for residential, commercial, and industrial uses and the accompanying infrastructure. Urbanization effects may include alterations to water quality, water quantity, and instream and streamside habitat (Ren et al. 2003, p. 649; Wilson 2015, p. 424). The effects on habitat also include variability in streamflow, typically increasing the extent and volume of water entering a stream after a storm and decreasing the time it takes for the water to travel over the land before entering the stream (Giddings et al. 2009, p. 1). In urbanized environments, storm drains deliver large volumes of water to streams much faster than would naturally occur, often resulting in flooding and bank erosion that reshape the channel and cause substrate instability. Increased, high-velocity discharges can cause species living in streams (including mussels) to become stressed, displaced, or killed by fastmoving water and the debris and sediment carried in it. Once floodwaters recede, displaced individuals may be left stranded out of the water, and fine sediments transported to the stream settle on coarser substrates, which may damage or destroy areas of mussel habitat. During storm events, contaminants in urbanized environments (e.g., gasoline, oil drips, fertilizers) accumulated on impervious surfaces may be washed directly into streams (USFWS, 2023)

Stressor: Energy Development—Coal, Natural Gas, and Oil (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Extraction of coal, natural gas, and (to a lesser extent) oil is common in the Cumberland and Upper Tennessee River basins and has been associated with mussel declines in several watersheds (Layzer and Anderson 1992, entire; Warren and Haag 2005, entire; Johnson et al. 2014, p. 890; TDEC 2014, p. 62; Zipper et al. 2016, pp. 612–613; Ahlstedt et al. 2016, p. 13). Examples of energy development impacts in the range of the three mussels include high levels of

copper, manganese, and zinc, metals that can be toxic to freshwater mussels, found in sediment samples from both the Clinch and Powell Rivers. Both rivers receive runoff from active, reclaimed, and abandoned coal mine sites. In Cumberland Basin streams, including Buck Creek, Horse Lick Creek, Little South Fork, and Rockcastle River, there was a clear correlation between surface mines, increased metal concentrations downstream, and the extirpation of some mussel species (Layzer and Anderson 1992, pp. 91–96). In the upper Powell River, Virginia, coal mining has almost eliminated the mussel fauna; sediment pore water from the riverbed contains levels of contaminants potentially toxic to mussels, particularly selenium and copper (Timpano et al. 2023, p. 13). Natural gas and oil extraction is a threat to freshwater mussels in the Upper Tennessee Basin and Cumberland Basin. In addition to the general impacts of erosion and sedimentation from forest clearing for access roads and installing drill pads, spills from (brine) disposal ponds at gas wells or end-of-pipe discharges from brine treatment facilities can reduce freshwater mussel abundance and diversity, as well as increase mortality. These effects have been observed in the Allegheny River (Patnode et al. 2015, p. 55), a watershed outside the range of the three mussel species, but within the Ohio Basin, which contains the Tennessee River and Cumberland River (USFWS, 2023)

Stressor: Agriculture (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Throughout the range of the three mussel species and have impacted watersheds in the species' historical and current ranges. The advent of intensive row crop agriculture is a potential factor in freshwater mussel decline and species extirpation in the eastern United States (Peacock et al. 2005, p. 550). Nutrient enrichment from fertilized crops and livestock is a threat commonly associated with negative effects on aquatic biota and can increase ammonia concentrations, to which freshwater mussels are particularly sensitive. In addition, agricultural pesticides, including herbicides, fungicides, insecticides, and their surfactants and adjuvants, are highly toxic to juvenile and adult freshwater mussels (Bringolf et al. 2007, p. 2,092). Concentrations of these contaminants from fields or pastures may be at levels that can affect an entire population, especially given the highly fragmented distributions of the three mussel species. Agricultural land use has been associated with decreased freshwater mussel diversity, growth, and survival in North American streams. A temporal analysis of freshwater mussel populations in Iowa streams showed declines in mussel species richness, and local extirpations corresponded with agricultural intensity and forest clearing of the riparian zone (Poole and Downing 2004, pp. 121–124). In those Iowa streams, the segments with the highest substrate diversity exhibited the lowest declines in species richness, indicating homogenization of substrates from sedimentation is a freshwater mussel stressor. Further, species richness increased or was unchanged where agriculture was less than 25 percent of the land use. Another study, in Minnesota streams, revealed decreases in mussel abundance and richness corresponding with increases in agricultural land use (Hornbach et al. 2019, p. 1,833). In Kentucky, streams in proximity to row crop agriculture were associated with higher values of contaminants (pesticides and fertilizers), and growth of caged mussels in those streams was low in comparison with most other streams, where row crops were a minor land use (Haag et al. 2019, pp. 761–763). One of the streams in the study with high row crop land use was the Red River, in the historical range of the Cumberland moccasinshell and with one current low-condition population of the Tennessee clubshell. The abnormally low growth rates observed in the streams in proximity to high row crop land use usually presage early mortality observed in

mussel hatchery settings (USFWS, 2023)

Stressor: Contaminants (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Three of the land uses identified as threats to the three mussel species (urban development, energy development, and agriculture) contribute contaminants to stream habitats, which can degrade water and substrate quality and adversely impact individuals and populations. Although chemical spills and other point sources of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result in part from the subtle, pervasive effects of chronic, low-level contamination (USFWS, 2023)

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2020. Species Status Assessment for Three Freshwater Mussels from the Tennessee and Cumberland River Basins (Medionidus conradicus, Pleurobema oviforme, and Pleuronaia barnesiana), Version 1.0. Asheville Ecological Services Field Office, Asheville, North Carolina.
USFWS. 2023. FR Vol, 88, No. 161. Pages 57060-57077. Endangered and Threatened Wildlife and Plants

Endangered Species Status for Tennessee Clubshell, Tennessee Pigtoe, and Cumberland Moccasinshell.

USFWS. 2023. FR Vol, 88, No. 161. Pages 57060-57077. Endangered and Threatened Wildlife and Plants

USFWS. 2023. FR Vol, 88, No. 161. Pages 57060-57077. Endangered and Threatened Wildlife and Plants

SPECIES ACCOUNT: *Medionidus parvulus* (Coosa moccasinshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; March 17, 1993; Southeast Region (R4) (USFWS 2008)

Physical Description

This is a small species occasionally exceeding 40 mm (1.6 in) in length. Shell is thin, elongate, and elliptical to squarish in outline. Posterior ridge inflated, smoothly rounded, terminating in a broadly rounded point; the posterior slope is finely corrugated. Periostracum is yellow-brown to dark brown, with fine green rays. Nacre blue, occasionally with salmon-colored spots (USFWS 2000).

Taxonomy

Genetic analysis is needed to determine the proper identification of some populations (e.g., Medionidus specimens from the Conasauga River).ted that they integrated. Johnson (1977) synonymized M. parvulus with M. acutissimus. Genetic analysis is needed to determine the proper identification of some populations (e.g., Medionidus specimens from the Conasauga River). The relationship of Medionidus acutissimus to Medionidus parvulus is unclear as the two overlap in shell morphology in parts of their ranges (Williams et al., 2008) (NatureServe 2015).

Historical Range

Historically, this species occurred in the Cahaba River, Alabama; Sipsey Fork, Black Warrior River drainage, Alabama; Coosa River and tributaries, Alabama, Georgia, Tennessee (USFWS 2000).

Current Range

Since listing, presence has been confirmed in the Conasauga River Murray/Whitefield county, GA; Bradley county, TN) and Holly Creek (Murray county, GA) (Johnson and Evans, 2000; Williams and Hughes, 1998) (USFWS 2008).

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the Coosa moccasinshell, under the Endangered Species Act of 1973, as amended (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat is designated for the Coosa moccasinshell (Medionidus parvulus), in Units 18, 19, 20, 21, 22, 23, 24, 25, 26; in AL, GA, and TN.

Unit 19. Hatchet Creek, Coosa, Clay Counties, Alabama. Unit 19 encompasses 66 km (41 mi) of the Hatchet Creek channel in Alabama, extending from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama. The fine-lined pocketbook occurs within this reach (Feminella and Gangloff, 2000; Pierson, 1992b). Hatchet Creek is within the historic range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, southern clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 22. Cheaha Creek, Talladega, Clay Counties, Alabama. Unit 22 encompasses 27 km (17 mi) of the Cheaha Creek channel, extending from its confluence with Choccolocco Creek, Talladega County, Alabama, upstream to the tailwater of Chinnabee Lake, Clay County, Alabama. The finelined pocketbook and southern pigtoe survive within this reach (Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson, 1992b, 1993). Cheaha Creek is in the historic range of the Coosa moccasinshell and triangular kidneyshell.

Unit 26. Lower Coosa River, Elmore County, Alabama. Unit 26 encompasses 13 km (8 mi) of the Lower Coosa River channel, extending from Alabama State Highway 111 bridge, upstream to Jordan Dam, Elmore County, Alabama. This river reach is within the historic range of fine-lined pocketbook, southern clubshell, Alabama moccasinshell, Coosa moccasinshell, ovate clubshell, southern pigtoe, triangular kidneyshell, upland combshell, and southern acornshell. (Johnson, 2002; Pierson, 1991a).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the Coosa moccasinshell (Medionidus parvulus) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: All mussels are filter feeders. Oxygen-bearing water and food are drawn into the incurrent siphon, and waste-carrying water is simultaneously passed out the excurrent siphon. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS 2000).

Reproduction Narrative

Adult: This species probably releases glochidia in the spring. Glochidia transform on blackbanded darters, however other species of darters are also likely hosts (P. Johnson, pers. Comm., 2002) (USFWS 2008). While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years (USFWS 2000).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, dams (NatureServe 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from USFWS 2000)

Environmental Specificity

Adult: Narrow to very narrow (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species is usually completely buried in the stream bottom (USFWS 2008). It inhabits sand/gravel/cobble shoals with moderate to strong currents in streams and small rivers (USFWS 2000). The environmental specificity of this species is narrow to very narrow. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls.

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe 2015)

Dispersal

Adult: Low (NatureServe 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe 2015).

Population Information and Trends

Population Trends:

> 90 % decline (NatureServe 2015)

Species Trends:

Stable (NatureServe 2015)

Number of Populations:

2 (NatureServe 2015)

Population Size:

= 1,000 individuals

Adaptability:

Low (inferred from NatureServe 2015)

Population Narrative:

The status of the species is unknown, based on the 2007 Date Recovery Call. No genetic information is available. It is vulnerable to extinction due to extreme curtailment of range and habitat, low numbers, and impacts from pollution and stochastic events (USFWS 2008). The range extent of this species is 100 - 400 square miles, with an estimated population size of up to 1,000 individuals. There are currently two known populations, neither of which have good viability/integrity. The population in the Conasauga River appears to be stable at the present time but this species has experienced a long-term decline of greater than 90% (NatureServe 2015).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species. The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin. Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a mollusk-eating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: All populations of this species are susceptible to stochastic and chronic events (e.g., spills, drought and/or landuse runoff) (USFWS, 2008).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:
This species has a final, approved recovery plan, however, recovery criteria were not specified because of the extent of decline, habitat loss and fragmentation, population isolation, and continuing impacts on their habitats (USFWS 2008).

Delisting Criteria:
Coosa moccasinshell and southern pigtoe 1) At least six (6) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (Factors A and E). 2) At least four (4) populations (as defined in Criteria 1) occupy four of the six HUC8 watersheds (Conasauga, Coosawattee, Oostanaula, Upper Coosa, Middle Coosa, and Lower Coosa), and one (1) population occupies the main stem of the Oostanaula or the Coosa River to protect against extinction from catastrophic events and maintain adaptive potential. a) One (1) additional population (as defined in Criteria 1) of Coosa moccasinshell occupies the Cahaba, Upper Black Warrior, or Lower Black Warrior HUC8. 3) Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A, C, D, and E) (USFWS, 2019).

Recovery Actions:
- Protect habitat integrity and quality (USFWS 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS 2000).

- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS 2000).
- Develop measurable recovery criteria (USFWS 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS 2008).
- Develop and implement plan to describe and monitor habitat conditions (USFWS 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife service Southeast Region Ecological Services. Jackson, Mississippi

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 4, 2016).

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2019. Coosa moccasinshell and Southern pigtoe Amendment 1 to the U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Medionidus penicillatus* (Gulf moccasinshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4) (USFWS, 2003)

Physical Description

A small, sculptured, rayed freshwater mussel. See Johnson (1977) and Deyrup and Franz (1994). The shell is elongate-elliptical or rhomboidal and fairly inflated, and has relatively thin valves. Ventral margin is nearly straight or slightly rounded. Females tend to have the posterior point above the ventral margin and are somewhat more inflated. Sculpturing consists of a series of thin, radially oriented plication along the length of the posterior slope. The remainder of the surface is smooth and yellowish to greenish brown with fine, typically interrupted green rays. Nacre color is smokey purple or greenish and slightly iridescent at the posterior end (Butler and Alam, 1999). The Length is 5 cm and the width is 2 cm (NatureServe, 2015).

Taxonomy

van der Schalie (1940) reported two species of Medionidus penicillatus from the Chipola River, M. penicillatus and Medionidus kingi. M. kingi was later synonomized under M. penicillatus by Clench and Turner (1956), who recognized only one species of Medionidus from the Suwannee, Ochlockonee, and Apalachicola River systems (Brim Box and Williams 2000). Their records of M. penicillatus from the Ochlockonee River are now recognized as Medionidus simpsonianus, and their Suwannee River records are now recognized as Medionidus walkeri; with Medionidus penicillatus restricted to the Apalachicola basin (Williams et al., 2008). Unlike previous authors (Johnson, 1977; Butler, 1989), Brim Box and Williams (2000) restricted the distribution of Medionidus penicillatus to the ACF and Econfina Creek drainages, based on zoogeographic considerations (with Medionidus from west of the ACF basin assigned to Medionidus acutissimus). Taxonomic questions exist as to the relationship between Mobile Basin M. acutissimus and what appears to be that species in the Choctawhatchee, Yellow, and Escambia drainages as slight conchological differences exist. M. acutissimus from the Escambia, Yellow, and Choctawhatchee River drainages are also similar morphologically to Medionidus penicillatus and some authors have included those populations in the range of M. penicillatus (Johnson, 1977; Butler, 1990; Williams and Butler, 1994), but those populations are included in the range of M. acutissimus by Williams et al. (2008) because faunal distribution patterns suggest that faunas in the Choctawhatchee, Yellow, and Escambia River drainages are more closely related to those of the Mobile Basin than those of the Apalachicola Basin (NatureServe, 2015).

Historical Range

Historical sites listed by Johnson (1977) include Yellow River drainage, Alabama; Econfina Creek (= St. Andrews Bay) drainage, Florida; Chipola River drainage, Alabama; Chattahoochee River drainage, Georgia; Apalachicola River drainage, Florida (see Clench and Turner, 1956); and Flint River drainage, Georgia. It appears to be extirpated from historical localities in the Chattahoochee River main stem and all of Alabama (barely hanging on still in one site in Chipola headwaters area); some Chattahoochee River system streams (Mulberry, Uchee, Little Uchee Creeks); some Flint River tributaries (Line, Patsiliga, Turkey, Sandy Mount, Gum, Cedar, Jones, Abrams, Mill, Ichawaynochaway, and Spring Creeks); the Apalachicola River main stem; and some tributaries in the Chipola River system (Big, Marshall, Cowarts, Dry, Rocky, and both Spring Creeks; also both the Flint and Chipola River main stems). It is apparently extirpated from historical occurrences in Alabama (Chattahoochee River drainage) (USFWS, 2003; Butler, 1989; Williams et al., 2008) (NatureServe, 2015).

Current Range

The Gulf moccasinshell historically occurred in 11 sub-basins and currently occupies the Upper Flint, Middle Flint, Ichawaynochaway, Lower Chattahoochee, Chipola and Econfina Creek subbasins. The Gulf moccasinshell is likely extirpated from the Upper and Middle Chattahoochee sub-basins; there have been no records of occurrence since the 1970s (Brim Box and Williams 2000). The Service and GADNR have conducted extensive surveys of the Spring Creek sub-basin since 2000 (USFWS, unpub. data; GADNR, unpub. data); the species was not found during these surveys and it is likely extirpated. The Upper Flint sub-basin had one occurrence in 2014 from Whitewater Creek (GADNR, unpub. data). Chokee Creek in the Middle Flint sub-basin had yearly occurrences from 2008 to 2018 with evidence of recruitment (GADNR, unpub. data). The Ichawaynochaway sub-basin had one occurrence in 2014 from Chickasawhatchee Creek (GADNR, unpub. data). In the Lower Chattahoochee sub-basin, the Gulf moccasinshell is limited to the Sawhatchee Creek system, Early County, Georgia. This is the largest known assemblage of this species in Georgia. They are located throughout this system and show evidence of recruitment. Service and GADNR biologists have tagged 412 Gulf moccasinshells from yearly surveys (2005-2018) in a 100 meter (328 ft.) stretch of Sawhatchee Creek (GADNR, unpub. data). The Chipola sub-basin had several occurrences in three tributaries (Spring, Baker, and Dry Creeks) in 2012 with one additional occurrence in 2014 (Dry Creek) (USFWS, unpub. data; USGS, unpub. data). Econfina Creek had three occurrences in 2009 and one in 2015 (USFWS, unpub. data). (USFWS, 2019)

Critical Habitat Designated

Yes; 11/15/2007.

Legal Description

On November 15, 2007, the U.S. Fish and Wildlife Service designated critical habitat for the Gulf moccasinshell (Medionidus penicillatus) under the Endangered Species Act of 1973, as amended (72 FR 64286 - 64340).

Critical Habitat Designation

Critical habitat for the Gulf moccasinshell is designated in Econfina Creek, FL; Chipola River, AL, FL; Sawhatchee Creek and Kirkland Creek, GA; Upper Flint River, GA; Middle Flint River, GA; Lower Flint River, GA.

Unit 1: Econfina Creek, Florida. Unit 1 includes the main stem of Econfina Creek and one of its tributaries in Bay and Washington counties, Florida, encompassing a total stream length of 31.4 km (19.5 mi). The main stem of Econfina Creek as designated extends from its confluence with Deer Point Lake at the powerline crossing located 3.8 km (2.3 miles) downstream of Bay County Highway 388, Bay County, Florida, upstream 28.6 km (17.8 mi) to Tenmile Creek in Washington County, Florida. Unit 1 also includes the tributary stream Moccasin Creek from its confluence with Econfina Creek upstream 2.8 km (1.7 mi) to Ellis Branch in Bay County. Unit 1 is designated for the Gulf moccasinshell and oval pigtoe (Blalock-Herod unpub. data 2002–03; Brim Box unpub. data 1996; Williams unpub. data 1993). PCEs in Unit 1 are vulnerable to impacts from sedimentation, urbanization, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 4: Sawhatchee Creek and Kirkland Creek, Georgia. Unit 4 includes the main stems of Sawhatchee Creek and Kirkland Creek and one tributary of Sawhatchee Creek, encompassing a total stream length of 37.8 km (23.5 mi) in Early County, GA. The main stem of Sawhatchee Creek as designated extends from its confluence with the Chattahoochee River upstream 28.6 km (17.8 mi) to the powerline crossing located 1.4 km (0.87 mi) upstream of County Road 15, Early County, GA. The main stem of Kirkland Creek extends from its confluence with the Chattahoochee River upstream 6.1 km (3.8 mi) to Dry Creek, Early County, GA. The tributary, Sheffield Mill Creek, is included from its confluence with Sawhatchee Creek upstream 3.1 km (1.9 mi) to the powerline crossing located 2.3 km (1.4 mi) upstream of Sowhatchee Road, Early County, GA. Unit 4 is designated for the shinyrayed pocketbook, Gulf moccasinshell, and oval pigtoe (Brim Box and Williams 2000, p. 109–110, 113–114, 116–117; Abbott pers. comm. 2005; Stringfellow pers. comm. 2003). PCEs in Unit 4 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’

Unit 5: Upper Flint River, Georgia. Unit 5 includes the main stem of the Flint River and eight of its tributaries upstream of Lake Blackshear, plus two tributaries that flow into Lake Blackshear, encompassing a total stream length of 380.4 km (236.4 mi) in Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia. The main stem of the Flint River in designated Unit 5 extends from the State Highway 27 bridge (Vienna Road) in Dooly and Sumter counties, Georgia (the river is the county boundary), upstream 247.4 km (153.7 mi) to Horton Creek in Fayette and Spalding counties, Georgia (the river is the county boundary). The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributary streams in Unit 5 are: Swift Creek, from Lake Blackshear upstream 11.3 km (7 mi) to Rattlesnake Branch in Crisp and Worth counties, Georgia (the creek is the county boundary); Limestone Creek, from Lake Blackshear in Crisp County, Georgia, upstream 8.8 km (5.5 mi) to County Road 89 in Dooly County, Georgia; Turkey Creek, from the Flint River upstream 21.7 km (13.5 mi) to Rogers Branch in Dooly County, Georgia; Pennahatchee Creek, from Turkey Creek upstream 4.8 km (3 mi) to Little Pennahatchee Creek in Dooly County, Georgia; Little Pennahatchee Creek, from Pennahatchee Creek upstream 5.8 km (3.6 mi) to Rock Hill Creek in Dooly County, Georgia; Hogcrawl Creek, from the Flint River upstream 21.6 km (13.4 mi) to Little Creek in Dooly and Macon counties, Georgia (the creek is the county boundary); Red Oak Creek, from the Flint River upstream 21.7 km (13.5 mi) to Brittens Creek in Meriwether County, Georgia; Line Creek, from the Flint River upstream 15.8 km (9.8 mi) to Whitewater Creek in Coweta and Fayette counties, Georgia (the creek is the county boundary); and Whitewater Creek, from Line Creek upstream 21.5 km (13.4 mi) to Ginger Cake Creek in Fayette County, Georgia. Unit 5 is designated for the shinyrayed pocketbook (Dinkins pers. comm. 1999, 2003; P.D. Johnson pers. comm. 2003; Brim Box and Williams 2000, p. 109–110; Roe 2000; L. Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); Gulf moccasinshell (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002; Brim Box and Williams 2000, p. 113–114; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); oval pigtoe (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002, 2003; Stringfellow pers. comm. 2000, 2003; Abbott pers. comm. 2001; Brim Box and Williams 2000, p. 116–117; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997); and purple bankclimber (Winterringer CCR pers. comm. 2003; Dinkins pers. comm. 2003; P.D. Johnson pers. comm. 2003; Albanese pers. comm. 2003 regarding unpub. data from De Genachete and CCR; Brim Box and

Williams 2000, p. 105–106; E. Van De Genachete pers. comm. 1999). PCEs in Unit 5 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’ Unit 5 is divided into two maps in the Regulation Promulgation section of this rule, one for the southern part and one for the northern part of the unit. The ‘‘match line’’ for joining these two maps is where the county boundary between Crawford and Upson counties, Georgia, meets the Flint River.

Unit 6: Middle Flint River, Georgia. Unit 6 includes the main stem of the Flint River between Lake Worth (impounded by the Flint River Dam near Albany) and the Warwick Dam (which impounds Lake Blackshear), and nine tributaries, encompassing a total stream length of 302.3 km (187.8 mi) in Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia. The main stem of the Flint River in Unit 6 extends from Piney Woods Creek in Dougherty County, Georgia (the approximate upstream extent of Lake Worth), upstream 39.9 km (24.8 mi) to the Warwick Dam in Lee and Worth counties, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Middle Flint River in Unit 6 are: Kinchafoonee Creek, from the LeeDougherty county line (the approximate upstream extent of Lake Worth) upstream 107.6 km (66.8 mi) to Dry Creek in Webster County, Georgia; Lanahassee Creek, from Kinchafoonee Creek upstream 9.3 km (5.8 mi) to West Fork Lanahassee Creek in Webster County, Georgia; Muckalee Creek, from the Lee-Dougherty county line (the approximate upstream extent of Lake Worth) upstream 104.5 km (64.9 mi) to County Road 114 in Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km (4.5 mi) to Galey Creek in Schley County, Georgia; Mill Creek, from the Flint River upstream 3.2 km (2 mi) to Mercer Millpond Creek in Worth County, Georgia; Mercer Millpond Creek, from Mill Creek upstream 0.45 km (0.28 mi) to Mercer Millpond in Worth County, Georgia; Abrams Creek, from the Flint River upstream 15.9 km (9.9 mi) to County Road 123 in Worth County, Georgia; Jones Creek, from the Flint River upstream 3.8 km (2.4 mi) to County Road 123 in Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km (6.5 mi) to Dry Branch Creek in Lee County, Georgia. Unit 6 is designated for the shinyrayed pocketbook (Crow CCR pers. comm. 2004; Edwards Pittman Environmental 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; McCafferty pers. comm. 2000, 2001; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; BlalockHerod unpub. data 1997; Dinkins pers. comm. 1995; Brim Box and Williams 2000, p. 109–110), Gulf moccasinshell (Wisnewski unpub. data 2005; DeGarmo unpub. data 2002; Albanese pers. comm. 2003 regarding unpub. data from D. Shelton; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113– 114; Weston 1995), oval pigtoe (Wisnewski unpub. data 2005; Crow CCR pers. comm. 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; Stringfellow unpub. data 2002; Golladay unpub. data 2001, 2002; Brim Box and Williams 2000, p. 116–117; P. Johnson unpub. data 1999; Blalock-Herod unpub. data 1997; Weston 1995), and purple bankclimber (Tarbell 2004; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 6 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’ Unit 6 is divided into two maps in the Regulation Promulgation section of this rule, one for the western part and one for the eastern part of the unit. The ‘‘match line’’ for joining these two maps is Lake Worth in Dougherty County, Georgia.

Unit 7: Lower Flint River, Georgia. Unit 7 includes the main stem of the Flint River between Lake Seminole (impounded by the Jim Woodruff Lock and Dam) and the Flint River Dam (which impounds Lake Worth), and nine tributaries, encompassing a total stream length of 396.7 km (246.5 mi) in Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, GA. The main stem of the Flint River in Unit 7 extends from its confluence with Big Slough in Decatur County, GA (the approximate upstream extent of Lake Seminole) upstream 116.4 km (72.3 mi) to the Flint River Dam in Dougherty County, GA. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Lower Flint River in Unit 7 are: Spring Creek, from Smith Landing in Decatur County, Georgia (the approximate upstream extent of Lake Seminole), upstream 74.2 km (46.1 mi) to County Road 35 in Early County, Georgia; Aycocks Creek, from Spring Creek upstream 15.9 km (9.9 mi) to Cypress Creek in Miller County, Georgia; Dry Creek, from Spring Creek upstream 9.9 km (6.1 mi) to Wamble Creek in Early County, Georgia; Ichawaynochaway Creek, from the Flint River in Baker County, Georgia, upstream 68.6 km (42.6 mi) to Merrett Creek in Calhoun County, Georgia; Mill Creek, from Ichawaynochaway Creek upstream 7.4 km (4.6 mi) to County Road 163 in Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km (11.8 mi) to Little Pachitla Creek in Calhoun County, Georgia; Little Pachitla Creek, from Pachitla Creek upstream 5.8 km (3.6 mi) to Bear Branch in Calhoun County, Georgia; Chickasawhatchee Creek, from Ichawaynochaway Creek in Baker County, GA, upstream 64.5 km (40.1 mi) to U.S. Highway 82 in Terrell County, Georgia; and Cooleewahee Creek, from the Flint River upstream 15.1 km (9.4 mi) to Piney Woods Branch in Baker County, Georgia. Unit 7 is designated for the shinyrayed pocketbook (Gangloff 2005; McCafferty pers. comm. 2004; Stringfellow unpub. data 2003; Dinkins pers. comm. 2001, 2003; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Albanese pers. comm. 2003 regarding unpub. data from CCR; Andrews pers. comm. 2000; BlalockHerod unpub. data 1997; Brim Box and Williams 2000, p. 109–110; Butler unpub. data 1993), Gulf moccasinshell (Abbott pers. comm. 2005; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113–114; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), oval pigtoe (Dinkins pers. comm. 2001; Golladay unpub. data 2001, 2002; Andrews pers. comm. 2000; Brim Box and Williams 2000, p. 116– 117; P. Johnson unpub. data 1999; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), and purple bankclimber (S. Carlson unpub. data 2002; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 7 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements of critical habitat are:

(i) A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);

(ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay;

(iii) Permanently flowing water;

(iv) Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387); and

(v) Fish hosts (such as largemouth bass, sailfin shiner, brown darter) that support the larval life stages of the seven mussels.

Special Management Considerations or Protections

Activities in or adjacent to each of the critical habitat units may affect one or more of the PCEs that are found in the unit.

Management considerations to deal with sedimnetation include protecting streams from sedimentation through application of agricultural and forestry best management practices, avoiding soiland vegetation-disturbing activity in the riparian zone, restoring unstable stream channels and other erosive areas, and other practices that prevent or reduce erosion.

Management considerations to deal with the threat of channel instability include avoiding soil- and vegetation-disturbing activity in the riparian zone, limiting impervious surface area, and other urban storm water runoff control methods. Sand and gravel mining (unit 3), dredging and channelization (unit 8), and dam construction (unit 5) may also affect channel stability.

Measures to deal with construction and operation of dams, water withdrawals, and water diversions include water conservation and operational strategies that manage water storage capacity and water demands in combination to minimize departures from the natural flow regime.

Management considerations to deal with the threat of pollution include applying agricultural and forestry best management practices, preserving native vegetation in riparian zones, maintaining septic systems, and taking other measures to minimize pollutantladen runoff to streams.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels are parasitic on fish and there may be a specificity among some species. Food Habits: Parasitic (Immature), Detritivore (Adult) (NatureServe, 2015). Adult freshwater mussels are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Based on the findings of studies such as Baldwin and Newell (1991) and Neves et al. (1996), an omnivorous opportunistic diet would allow mussels to take advantage of whatever food type happens to be abundant. Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994) (USFWS, 2003).

Reproduction Narrative

Adult: Gulf moccasinshell glochidia are released in early to late spring, while gravid females were found in March, April, September, and November (O'Brien and Williams, 2002). The presence of gravid specimens of this lampsiline species in late summer and fall months suggests that the Gulf moccasinshell is a parent overwintering, summer releasing species. Glochidial morphology was described and figured by O'Brien and Williams (2002). Primary host fish include Etheostoma edwini (brown darter), Percina nigrofasciata (blackbanded darter), Gambusia holbrooki (eastern mosquitofish), Poecilia reticulata (guppy) (Butler and Alam, 1999; USFWS, 2003; O'Brien, 1998; O'Brien and Williams, 2002). Two other fishes, the eastern mosquitofish and guppy, also transformed glochidia but at lower percentage rates (O'Brien and Williams, 2002). (NatureServe, 2015) Female mussels may produce 75,000 to 3.5 million glochidia (Surber 1912, p. 3–10; Coker et al. 1921, p. 144; Yeager and Neves 1986, p. 333). The Gulf moccasinshell is probably a host-fish specialist that primarily parasitizes darters (USFWS, 2007a). No age specific information is available for these seven species, however closely related species are known to live 24 - 56 years (Moyer and Neves 1984). The age of sexual maturity for mussels is variable, usually requiring from three (Zale and Neves 1982) to nine (Smith 1979) years (USFWS, 2003). Four potential darter species demonstrated successful transformation in laboratory conditions for the Gulf moccasinshell; turquoise darter (Etheostoma inscriptum), gulf darter (Etheostoma swaini), halloween darter (Percina crypta), and blackbanded darter (Percina nigrofasciata). Metamorphosis success varied but was the highest on turquoise darter (40%) and blackbanded darter (39%). (USFWS, 2020)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: It occurs in a wide range of habitats, including sandy areas with a slight current (Jenkinson, 1973), streams and rivers where there is a moderate current and sand and gravel substrates (Clench and Turner, 1956), and in muddy sand substrates around tree roots in medium-sized stream with moderate current (Heard, 1975) (NatureServe, 2015). Primary constituent elements include: a geomorphically stable stream channel; a predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay; permanently flowing water; water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (CWA) (USFWS, 2007a).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Greatest potential during glochidial stage on fish. Adults of this species are essentially sessile however some passive movement downstream may occur during high flows. This species is non-migratory. (NatureServe, 2015)

Population Information and Trends

Population Trends:

70 - 90% decline (NatureServe, 2015)

Species Trends:

Unknown (USFWS, 2007b)

Number of Populations:

21 subpopulations (NatureServe, 2015)

Population Size:

1000 - 2500 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from USFWS, 2003)

Population Narrative:

This species is highly restricted in distribution, occurs in generally small subpopulations, and shows little evidence of recovering from historical habitat losses without significant positive human intervention. The Gulf moccasinshell once occurred in1,142 rm in Econfina Creek and the ACF river basin, and has lost 80 percent of its historic range. It is currently found in 21 subpopulations spread over 234 rm in 6 watersheds (USFWS, 2003). Historically several collections contained over 50 individuals of Medionidus penicillatus and Johnson (1977) listed it as relatively abundant in the Apalachicola River system, especially the Flint River drainage, but scarce elsewhere. In the ACF Basin (= formed by Apalachicola, Chattahoochee and Flint Rivers) of Alabama, Florida, and Georgia, historically this species was known from 93 historical collections from 52 sites (Brim Box and Williams, 2000), but is now known from less than 20 occurrences in the Flint and Chattahoochee River as well as previous a Chipola River tributary, Chattahoochee River tributary, and two Flint River tributaries. In the Econfina Creek drainage, it is known from at least 2 occurrences. In a recent survey of over 300 sites in the ACF Basin, 13 M. penicillatus were found from a total of nine occurrences, or less than 3% of the sites surveyed (USFWS, 2003). This species has experienced a long-term decline of 70-90%. (NatureServe, 2015) The status of the species is unknown, as no recent information is available. (USFWS, 2007b)

Threats and Stressors

Stressor: Exploitation (USFWS, 2003)
Exposure:
Response:
Consequence:

Narrative: Exploitation by native Americans and for pearls and pearl buttons plus overcollection for scientific purposes (very localized, low impact, historical only) (USFWS, 2003)

Stressor: Habitat alteration (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Impoundment causing loss of habitat, loss of shoal habitat, thermal alterations, daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, coldwater releases, turbulence, high silt loads, and altered host fish distribution (widespread, high impact, ongoing). Gravel mining causing riparian forest clearing, channel modification, disrupted flow, water quality modification, impacts on host fish populations, substrate disturbance/siltation, pollution (moderate scope, high impact, historical and ongoing). (USFWS, 2003)

Stressor: Contaminants (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Heavy metals, arsenic and ammonia from poultry and animal feedlots, industrial/municipal effluent, agricultural nutrient enrichment from poultry farms and livestock feedlots, herbicides/pesticides, nutrients from aquaculture ponds, urban stormwater runoff, municipal waste discharge (high-moderate scope, high impact, historical and ongoing) (USFWS, 2003)

Stressor: Sedimentation (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Sedimentation from agricultural, silvicultural, and roadway activities, clearing of riparian vegetation, and flood control activities, gravel mining, livestock grazing (high-moderate scope, high impact, historical and ongoing) (USFWS, 2003)

Stressor: Urbanization (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Highways, infrastructure, recreational activities (low scope, moderate-low impact, historical and ongoing) (USFWS, 2003)

Stressor: Logging (USFWS 2003)
Exposure:
Response:
Consequence:
Narrative: "Deadhead logging "causes disruption of habitat, increased sediment (localized in Florida only, moderate impact, potential future threat). (USFWS, 2003)

Stressor: Water withdrawals (USFWS, 2003)
Exposure:

Response:
Consequence:
Narrative: Water withdrawal mostly for irrigation (moderate impact, moderate scope, ongoing). (USFWS, 2003)

Stressor: Introduced species (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Asiatic clam, zebra mussel, and black carp have been introduced within the range of this species (moderate-low scope, moderate impact, ongoing). Yeager et al. (2000) determined that high densities of Asian clams negatively impacted survival and growth of newly metamorphosed juvenile mussels and thus reduced recruitment. Zebra mussels in the Great Lakes have attached in large numbers (up to 10,000 per unionid) to the shells of live native mussels (Schloesser and Kovalak 1991), and have been implicated in the loss of mussel beds (Hunter and Bailey 1992, Masteller et al. 1993, Schloesser and Nalepa 1995). A molluscivore (mollusk eater), the black carp has been proposed for widespread use by aquaculturists to control snails, the intermediate host of a trematode (flatworm) parasite affecting catfish in ponds in the Southeast. One of several Asian carp species intentionally brought to the U.S., black carp are known to eat clams (Corbicula spp.) and unionid mussels in China in addition to snails. (USFWS, 2003)

Recovery

Reclassification Criteria:
1. The species has shown an increase in its current range to reflect occupation of at least 50 percent of its historic range. (USFWS, 2007b)

2. The species has at least three viable subpopulations in each of the watersheds that currently support the species. (USFWS, 2007b)

3. The species has at least ten viable subpopulations in the large river basins within the historic range of the species for at least 3 generations. (USFWS, 2007b)

Delisting Criteria:
Biennial monitoring shows that an increase of the current number of subpopulation/sites and extent of occurrence is enough to ensure population viability, reduce isolation among populations, and increase the potential for genetic exchange. Specific increases in subpopulations and river miles needed are currently unknown and will be determined by completing Recovery Tasks 1.3.6, 1.3.7, and 1.3.8. (USFWS, 2007b)

1. Populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes. Gulf Moccasinshell 1a) At least seven (7) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes. 2. The spatial distribution of populations (as described in Criterion 1) are sufficient to protect against extinction from catastrophic events and maintain adaptive potential. Gulf Moccasinshell 2a) At least one (1) population in each of the Econfina Creek, Chipola, Chattahoochee, and Flint River systems, and two populations being located within the major tributary sub-basins of the Flint

River. 3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future. (USFWS, 2019)

Recovery Actions:
- Secure extant subpopulations and currently occupied habitats and ensure subpopulation viability. (USFWS, 2003)
- Search for additional subpopulations of the species and suitable habitat. (USFWS, 2003)
- Determine through research and propagation technology the feasibility of augmenting extant subpopulations and reintroducing or reestablishing the species into historical habitat. (USFWS, 2003)
- Develop and implement a program to evaluate efforts and monitor subpopulation levels and habitat conditions of existing subpopulations, as well as newly discovered, reintroduced, or expanding subpopulations. (USFWS, 2003)
- Develop and utilize a public outreach and environmental education program. (USFWS, 2003)
- Assess the overall success of the recovery program and recommend actions. (USFWS, 2003)
- The subpopulation recovery criteria defining a subpopulation as a site is vague and less meaningful than actual density or population estimates. As the Service acquires more information about population characteristics, the Service should revise recovery criteria. The Service recommends using quantitative methods to monitor changes in population size with each sub-basin. (USFWS, 2007b)
- Define "viable subpopulation" through implementation of Recovery Tasks 1.3.6, 1.3.7, and 1.3.8. (USFWS, 2007b)
- Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders. (USFWS, 2007b)
- Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies. (USFWS, 2007b)
- Work with the EPA and States to modify numerical water quality criteria for ammonia and copper. (USFWS, 2007b)
- Develop and implement a program to monitor subpopulation levels and habitat conditions of existing subpopulations. (USFWS, 2007b)
- Continue re-evaluating threats to this species. (USFWS, 2007b)

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Define “viable population” through implementation of Recovery Tasks 1.3.6 and 1.3.7. 2. Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders. 3. Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies. 4. Assess the short and long-term effects of Hurricane Michael on the mussel populations in Spring and Econfina creeks. 5. Develop and implement a program to monitor population levels and habitat conditions of existing populations. 6. Identify and survey poorly explored suitable habitat in currently and historically occupied sub-basins where the species may be present in low numbers or where reintroduction may be feasible. (USFWS, 2020)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available

U.S. Fish and Wildlife Service. 2003. Recovery Plan for Endangered Fat Threeridge (Amblema neislerii), Shinyrayed Pocketbook (Lampsilis subangulata), Gulf Moccasinshell (Medionidus penicillatus), Ochlockonee Moccasinshell (Medionidus simpsonianus), and Oval Pigtoe (Pleurobema pyriforme)

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp. USFWS. 2019. Amendment 1. Recovery Plan for the Gulf Moccasinshell (Medioiiidus penidilatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elllploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata). https ://ecos.fws.gov/docs/recovery_plan/030930.pdf. 10 pp.

U.S. Fish and Wildlife Service. 2007. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Final rule. 72 FR 64286 - 64340 (November 15, 2007).

USFWS 2007a. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages

Final Rule. 72 Federal Register 220. November 15, 2007. Pages 64286 - 64340

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp. USFWS. 2020. Shinyrayed Pocketbook (Lampsilis subangulata (now known as Hamiota subangulata) Gulf Moccasinshell (Medionidus penicillatus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Office Athens, Georgia. 25 pp.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2007b. Gulf Moccasinshell 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp.

USFWS 2007b. Gulf Moccasinshell 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office, Panama City, Florida.

USFWS. 2019. Amendment 1. Recovery Plan for the Gulf Moccasinshell (Medioiiidus penidilatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elllploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata). https ://ecos.fws.gov/docs/recovery_plan/030930.pdf. 10 pp.

USFWS. 2020. Shinyrayed Pocketbook (Lampsilis subangulata (now known as Hamiota subangulata) Gulf Moccasinshell (Medionidus penicillatus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Office Athens, Georgia. 25 pp.

SPECIES ACCOUNT: *Medionidus simpsonianus* (Ochlockonee moccasinshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 3/16/1998; Southeast Region (Region 4) (USFWS, 2003)

Physical Description

A small, elongate, sculptured freshwater mussel. See Johnson (1977) and Deyrup and Franz (1994). This species is slightly elongate-elliptical in outline, the posterior end obtusely rounded at the shell's median line and the ventral margin broadly curved. The posterior ridge is moderately angular and covered in its entire length with well developed, irregular ridges. Sculpture may also extend onto the disk below the ridge. Surface texture is smooth. Color is light brown to yellowish green, with dark green rays formed by a series of connected chevrons or undulating lines across the length of the shell. Lateral teeth are thin and straight and pseudocardinal teeth are compressed. There are two laterals and two pseudocardinals in the left valve and one lateral and one pseudocardinal tooth in the right valve. Nacre is bluish white (Butler and Alam, 1999). The length is 4 cm and the width is 2 cm (NatureServe, 2015)

Taxonomy

Clench and Turner (1956) recognized only one species of Medionidus from the Suwannee, Ochlockonee, and Apalachicola River systems. Their records of Medionidus penicillatus from the Ochlockonee River are now recognized as Medionidus simpsonianus, and their Suwannee River records are now recognized as Medionidus walkeri (Johnson, 1977). (NatureServe, 2015)

Historical Range

This species is historically known from 21 collections from seven occurrences in Florida and Georgia. Six of the historical occurrences are on the Ochlockonee River main stem, including all of the Georgia occurrences (Grady Co.) and some Florida occurrences (Leon and Gadsen Cos.) (Johnson, 1977). Based on a recent survey, it appears to be extirpated from the single site from a tributary stream, the Little River in Florida. (NatureServe, 2015)

Current Range

This species is historically known from 21 collections from seven occurrences in Florida and Georgia. Six of the historical occurrences are on the Ochlockonee River main stem, including all of the Georgia occurrences (Grady Co.) and some Florida occurrences (Leon and Gadsen Cos.) (Johnson, 1977). Based on a recent survey, it appears to be extirpated from the single site from a tributary stream, the Little River in Florida. In 1993 all of the historical occurrences were resurveyed, as well as 66 new sites (J. Brim Box, pers. obs.) and it was found at two of the historical occurrences. It is restricted to a single river system, the Ochlockonee River in Georgia, and within the system, is now extant only in the main channel and not tributaries (USFWS, 2003) plus a single site on the river in Florida within 20 km of the Alabama state line (D. Jackson, FNAI, pers. comm., March 2008). (NatureServe, 2015)

Critical Habitat Designated

Yes; 11/15/2007.

Legal Description

On November 15, 2007, the U.S. Fish and Wildlife Service designated critical habitat for the Ochlockonee moccasinshell (Medionidus simpsonianus) under the Endangered Species Act of 1973, as amended (72 FR 64286 - 64340).

Critical Habitat Designation

Critical habitat is designated for the Ochlockonee moccasinshell (Medionidus simpsonianus) in Unit 9 in FL and GA.

Unit 9: Upper Ochlockonee River, Florida, Georgia. Unit 9 includes the main stem of the Ochlockonee River upstream of Lake Talquin (impounded by the Jackson Bluff Dam) and three tributaries, encompassing a total stream length of 177.3 km (110.2 mi) in Gadsden and Leon counties, Florida, and Grady and Thomas counties, Georgia. The main stem of the Ochlockonee River in Unit 9 extends from its confluence with Gulley Branch (the approximate upstream extent of Lake Talquin) in Gadsden and Leon counties, Florida (the river is the county boundary), upstream to Bee Line Road/County Road 306 in Thomas County, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The three tributary streams in Unit 9 are: Barnetts Creek, from the Ochlockonee River upstream 20 km (12.4 mi) to Grady County Road 170/Thomas County Road 74 in Grady and Thomas counties, Georgia (the creek is the county boundary); West Barnetts Creek, from Barnetts Creek upstream 10 km (6.2 mi) to GA Highway 111 in Grady County, Georgia; and Little Ochlockonee River, from the Ochlockonee River upstream 13.3 km (8.3 mi) to Roup Road/County Road 33 in Thomas County, Georgia. Unit 9 is designated for the shinyrayed pocketbook (Blalock-Herod 2003, p. 1; McCafferty pers. comm. 2003; Williams unpub. data 1993), Ochlockonee moccasinshell (Brim Box and Williams 2000, p. 60; Williams and Butler 1994, p. 64), oval pigtoe (Edwards Pittman Environmental 2004; Blalock-Herod unpub. data 2003; Blalock-Herod 2003, p. 1; Williams unpub. data 1993), and purple bankclimber (Blalock-Herod unpub. data 2003; Blalock-Herod 2002, p. 1; Smith FDOT unpub. data 2001; Williams unpub. data 1993). PCEs in Unit 9 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Primary Constituent Elements/Physical or Biological Features

The primary consituent elements of critical habitat are:

(i) A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);

(ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay;

(iii) Permanently flowing water;

(iv) Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387); and

(v) Fish hosts (such as largemouth bass, sailfin shiner, brown darter) that support the larval life stages of the seven mussels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on the effective date of this rule and not containing one or more of the primary constituent elements.

Activities in or adjacent to each of the critical habitat units may affect one or more of the PCEs that are found in the unit.

Management considerations to deal with sedimentation include protecting streams from sedimentation through application of agricultural and forestry best management practices, avoiding soiland vegetation-disturbing activity in the riparian zone, restoring unstable stream channels and other erosive areas, and other practices that prevent or reduce erosion.

Management considerations to deal with the threat of channel instability include avoiding soil- and vegetation-disturbing activity in the riparian zone, limiting impervious surface area, and other urban storm water runoff control methods. Sand and gravel mining (unit 3), dredging and channelization (unit 8), and dam construction (unit 5) may also affect channel stability.

Measures to deal with construction and operation of dams, water withdrawals, and water diversions include water conservation and operational strategies that manage water storage capacity and water demands in combination to minimize departures from the natural flow regime.

Management considerations to deal with the threat of pollution include applying agricultural and forestry best management practices, preserving native vegetation in riparian zones, maintaining septic systems, and taking other measures to minimize pollutantladen runoff to streams.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels are generally parasitic on fish and there may be a specificity among some species. Food Habits: Parasitic (Immature), Detritivore (Adult) (NatureServe, 2015). Adult freshwater mussels are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994). Based on the findings of studies such as Baldwin and Newell (1991) and Neves et al. (1996), an omnivorous opportunistic diet would allow mussels to take advantage of whatever food type happens to be abundant (USFWS, 2003).

Reproduction Narrative

Adult: The Service assumes its reproductive biology is similar to its congener, the Gulf moccasinshell, which uses darters as host fish (USFWS, 2007a). The Lampsilinae are generally bradytictic (Zale and Neves 1982). No age specific information is available for this species, however closely related species are known to live 24 to 56 years. Mature glochidia may number in the tens of thousands to several million (Surber 1912, Coker et al. 1921, Yeager and Neves 1986). The age of sexual maturity for mussels is variable, usually requiring from three (Zale and Neves 1982) to nine (Smith 1979) years (USFWS, 2003).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: It has been reported from muddy sand and sand in moderate current (Heard, 1979), and from sand and gravel substrates in moderate current (Deyrup and Franz, 1994). Deyrup and Franz (1994) also reported it from large creeks, although the basis for that observation is not clear, since there is only one historical record of this species from a tributary stream. In recent surveys it was found in large creeks of the Ochlockonee River main stem in areas with current in sandy substrates with some light gravel in mid-channel areas (J. Brim Box, pers. obs.; USFWS, 2003). This diminutive species is probably highly sensitive to sedimentation and habitat modifications. The environmental specificity of this species is narrow. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). Primary constituent elements include: a geomorphically stable stream channel; a predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay; permanently flowing water; water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (CWA) (USFWS, 2007a)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Greatest potential during glochidial stage on fish. Adults of this species are essentially sessile however some passive movement downstream may occur during high flows. This species is non-migratory. Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of >90% (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1 - 250 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

The species has been reduced to a point where recruitment and dispersal are severely hindered. Decline of nearly 100% of former historic occurrences (possibly one subpopulation extant) has occurred long-term (USFWS, 2003). This species has experienced a long-term decline of >90%. The range extent of this species is less than 40 square miles, with an estimated population size of 1 - 250 individuals. There are 1 - 5 occurrences, with none of these occurrences having good viability/integrity (NatureServe, 2015). It is unknown whether any subpopulations of the Ochlockonee moccasinshell persist (USFWS, 2003).

Threats and Stressors

Stressor: Exploitation (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Exploitation by native Americans and for pearls and pearl buttons plus overcollection for scientific purposes (very localized, low impact, historical only) (USFWS, 2003)

Stressor: Habitat alteration (USFWS, 2003)
Exposure:
Response:

Consequence:
Narrative: Impoundment causing loss of habitat, loss of shoal habitat, thermal alterations, daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, coldwater releases, turbulence, high silt loads, and altered host fish distribution (widespread, high impact, ongoing). Channelization for navigation and maintenance causing sedimentation and contamination (moderate scope, high impact, historical and ongoing). Gravel mining causing riparian forest clearing, channel modification, disrupted flow, water quality modification, impacts on host fish populations, substrate disturbance/siltation, pollution (moderate scope, high impact, historical and ongoing) (USFWS, 2003).

Stressor: Pollution (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Heavy metals, arsenic and ammonia from poultry and animal feedlots, industrial/municipal effluent, agricultural nutrient enrichment from poultry farms and livestock feedlots, herbicides/pesticides, nutrients from aquaculture ponds, urban stormwater runoff, municipal waste discharge (high-moderate scope, high impact, historical and ongoing) (USFWS, 2003)

Stressor: Sedimentation (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Sedimentation from agricultural, silvicultural, and roadway activities, clearing of riparian vegetation, and flood control activities, gravel mining, livestock grazing (high-moderate scope, high impact, historical and ongoing) (USFWS, 2003)

Stressor: Urbanization (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Highways, infrastructure, recreational activities (low scope, moderate-low impact, historical and ongoing) (USFWS, 2003).

Stressor: Logging (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: "Deadhead logging" causes disruption of habitat, increased sediment (localized in Florida only, moderate impact, potential future threat) (USFWS, 2003).

Stressor: Water withdrawals (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Water withdrawal, mostly for irrigation (moderate impact, moderate scope, ongoing) (USFWS, 2003).

Stressor: Introduced species (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: The Asiatic clam, zebra mussel, and black carp have been introduced within the range of this species (moderate-low scope, moderate impact, ongoing). Yeager et al. (2000) determined that high densities of Asian clams negatively impacted survival and growth of newly metamorphosed juvenile mussels and thus reduced recruitment. Zebra mussels in the Great Lakes have attached in large numbers (up to 10,000 per unionid) to the shells of live native mussels (Schloesser and Kovalak 1991), and have been implicated in the loss of mussel beds (Hunter and Bailey 1992, Masteller et al. 1993, Schloesser and Nalepa 1995). A molluscivore (mollusk eater), the black carp has been proposed for widespread use by aquaculturists to control snails, the intermediate host of a trematode (flatworm) parasite affecting catfish in ponds in the Southeast. One of several Asian carp species intentionally brought to the U.S., black carp are known to eat clams (Corbicula spp.) and unionid mussels in China in addition to snails (USFWS, 2003).

Recovery

Reclassification Criteria:
1. The species has shown an increase in its current range to reflect occupation of at least 50 percent of the total historical habitat (USFWS, 2003).

2. At least three viable subpopulations in each of the watersheds that currently supports the species (USFWS, 2003).

3. At least ten viable subpopulations in the large river basins (i.e., Apalachicola, Chattahoochee-Flint, Ochlockonee, Suwannee Rivers) within the historical range of the species, for at least 3 generations (USFWS, 2003).

Delisting Criteria:
(1) The one (1) Ochlockonee Moccasinshell population in the lower Ochlockonee River basin exhibits a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (USFWS, 2019).

(2) At least one (1) Ochlockonee Moccasinshell population is established or discovered in the upper Ochlockonee River basin that exhibits a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (USFWS, 2019).

(3) Spatial distribution of Ochlockonee Moccasinshell populations are sufficient to protect against extinction from catastrophic events and maintain adaptive potential (occupancy of at least 25 km (15.5 mi) of stream channel in the lower basin and 55 km (34.2 mi) of stream channel in the upper basin is needed to maintain each population) (USFWS, 2019).

(4) Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (USFWS, 2019).

Recovery Actions:

- Secure extant subpopulations and currently occupied habitats and ensure subpopulation viability (USFWS, 2003).
- Search for additional subpopulations of the species and suitable habitat (USFWS, 2003).
- Determine through research and propagation technology the feasibility of augmenting extant subpopulations and reintroducing or reestablishing the species into historical habitat (USFWS, 2003).
- Develop and implement a program to evaluate efforts and monitor subpopulation levels and habitat conditions of existing subpopulations, as well as newly discovered, reintroduced, or expanding subpopulations (USFWS, 2003).
- Develop and utilize a public outreach and environmental education program (USFWS, 2003).
- Assess the overall success of the recovery program and recommend actions (USFWS, 2003).
- The subpopulation recovery criteria defining a subpopulation as a site is vague and less meaningful than actual density or population estimates. As the Service acquires more information about population characteristics, the Service should revise recovery criteria. The Service recommends using quantitative methods to monitor changes in population size with each sub-basin (USFWS, 2007b).
- Define "viable subpopulation" through implementation of Recovery Tasks 1.3.6, 1.3.7, and 1.3.8 (USFWS, 2007b).
- Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders (USFWS, 2007b).
- Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies (USFWS, 2007b).
- Work with the EPA and States to modify numerical water quality criteria for ammonia and copper (USFWS, 2007b).
- Develop and implement a program to monitor subpopulation levels and habitat conditions of existing subpopulations (USFWS, 2007b).
- Continue re-evaluating threats to this species (USFWS, 2007b).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Conduct an eDNA surveys upstream of the reservoir to determine if a population still exists in the upper basin. • Model future sea level and flow scenarios in the lower Ochlockonee River to examine the vulnerability of the population to saltwater encroachment and storm surge events. • Conduct research on the negative effects of Asian Clam (Corbicula fluminea) on native unionids is needed to determine future conservation strategies of this and other species. • Incorporate detection analysis, occupancy modeling, and collection of size class data into monitoring efforts where possible. • Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders. • Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies. • Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans. • Prepare a comprehensive threat assessment of the Ochlockonee River basin. • Develop a Propagation and Reintroduction Plan for this species to determine when, where, and if population reintroduction would be appropriate for the recovery of the species. • Identify locations in the upper basin with suitable habitat for reintroduction efforts and conduct additional upper basin presence/absence surveys. • Update the Recovery Plan for this species. • Increase public awareness through various forms of outreach. (USFWS, 2020)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

U.S. Fish and Wildlife Service. 2003. Recovery Plan for Endangered Fat Threeridge (Amblema neislerii), Shinyrayed Pocketbook (Lampsilis subangulata), Gulf Moccasinshell (Medionidus penicillatus), Ochlockonee Moccasinshell (Medionidus simpsonianus), and Oval Pigtoe (Pleurobema pyriforme)

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp.

U.S. Fish and Wildlife Service. 2007. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Final rule. 72 FR 64286 - 64340 (November 15, 2007).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2007a. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages

Final Rule. 72 Federal Register 220. November 15, 2007. Pages 64286 - 64340

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

U.S. Fish and Wildlife Service Amendment to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for Ochlockonee Moccasinshell (Medionidus simpsonianus).

USFWS. 2019. Amendment 1 for the Recovery Plan for Ochiockonee Moccasinshell (Medionidus sirnpsonianus).

USFWS 2007b. Ochlockonee moccasinshell (Medionidus simpsonianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office, Panama City, Florida.

USFWS. 2020. Ochlockonee Moccasinshell (Medionidus simpsonianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Panama City Ecological Services Field Office Panama City, Florida. 21 pp.

SPECIES ACCOUNT: *Medionidus walkeri* (Suwannee moccasinshell)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/06/2016; Southeast Region (R4) (USFWS, 2016)

Physical Description

A freshwater mussel that rarely exceeds 50 millimeters (2.0 inches) in length. Its shell is oval in shape and sculptured with corrugations extending along the posterior ridge, although the corrugations are sometimes faint. The shell exterior (periostracum) is greenish yellow to brown with green rays of varying width and intensity in young individuals, and olive brown to brownish black with rays often obscured in mature individuals (Williams et al. 2014, p. 278). The sexes can be distinguished, with female shells being smaller and longer than the males (Johnson 1977, p. 177). Its sharp posterior ridge and generally dark, rayless shell distinguishes it from other species of Medionidus in Gulf drainages (Johnson 1977, p. 177; Williams and Butler 1994, p. 86) (USFWS, 2015).

Taxonomy

A member of the family Unionidae (USFWS, 2015). Clench and Turner (1956) recognized only one species of Medionidus from the Suwannee, Ochlockonee, and Apalachicola River systems. Their records of Medionidus penicillatus from the Ochlockonee River are now recognized as Medionidus simpsonianus, and their Suwannee River records are now recognized as Medionidus walkeri (Johnson, 1977) (NatureServe, 2015).

Historical Range

The Suwannee moccasinshell is endemic to the Suwannee River Basin in Florida and Georgia. The Suwannee moccasinshell's historical range includes the lower and middle Suwannee River proper, the Santa Fe River sub-basin, and the lower reach of the Withlacoochee River (Williams 2015, p. 7) (USFWS, 2015).

Current Range

The Suwannee moccasinshell's range has declined in recent decades, and it is presently known only from the Suwannee River main channel and the lower Santa Fe River in Florida. Within the Suwannee mainstem, the moccasinshell occurs intermittently throughout a 75- mile (121-kilometer) reach of the lower and middle river from river mile (RM) 50 in Dixie/Gilchrist Counties, upstream to RM 125, near the Withlacoochee River mouth. Within the Santa Fe sub-basin, the species is currently known from four localities (two are shell material only) in a 28-mile segment of the lower Santa Fe River downstream of the rise (USFWS, 2015). Santa Fe subbasin – The species currently occurs in a 36-kilometer (22-mile) reach of the lower Santa Fe River channel, where two live individuals and seven shells have been observed since 2005. Since being listed, surveyors conducted 32 unique sampling events throughout its range during 2016–2020 but did not detect the species. The Suwannee Moccasinshell was last observed upstream of the subterranean section in 1996 and is either below detectable levels or extirpated in this reach (Johnson et al. 2016). Its numbers are declining in the Santa Fe River, where it was lasted detected in 2015 and the species appears nearly extirpated in the subbasin. Its decline is attributed to decreases in stream flow and changes in water quality, especially increased nitrogen loads and algae growth (Service 2021). Lower Suwannee subbasin – The species currently occurs in a 124-kilometer (77-mile) reach of the middle Suwannee River, where 88 live individuals and 11 shells have been detected since 2005. Observations of multiple age classes and gravid females indicate the species is recruiting (FWC unpubl. data provided 9/13/2021). One relic shell found in 2015 extended its known range in the lower mainstem downstream by about 11.5-kilometers (7-mile); however, the species appears extirpated in the lower-most reach of the Suwannee River, generally downstream of Fanning Springs. Its extirpation in this reach is attributed to changes to water chemistry and habitat conditions as a result of flow declines and salt water encroachment (USFWS, 2022).

Critical Habitat Designated

Yes;

Legal Description

We, the U.S. Fish and Wildlife Service (Service), designate critical habitat for the Suwannee moccasinshell (Medionidus walkeri) under the Endangered Species Act of 1973 (Act), as amended. In total, approximately 190 miles (306 kilometers) of stream channels in Alachua, Bradford, Columbia, Dixie, Gilchrist, Hamilton, Lafayette, Madison, Suwannee, and Union Counties, Florida, and Brooks and Lowndes Counties, Georgia, fall within the boundaries of the critical habitat designation. The effect of this regulation is to designate critical habitat for the Suwannee moccasinshell under the Act. (USFWS, 2021)

Critical Habitat Designation

Unit 1: Suwannee River, Florida Unit 1 consists of approximately 187 km (116 mi) of the Suwannee River and lower Santa Fe River in Alachua, Columbia, Dixie, Gilchrist, Lafayette, Madison, and Suwannee Counties, Florida. The unit includes the Suwannee River mainstem from the confluence of Hart Springs (near river kilometer 71) in Dixie and Gilchrist Counties, upstream 137 km (85 mi) to the confluence of the Withlacoochee River in Madison and Suwannee Counties; and the Santa Fe River from its confluence with the Suwannee River in Suwannee and Gilchrist Counties, upstream 50 km (31 mi) to the river's rise in Alachua County. The Santa Fe River flows underground for about 5 km (3.1 mi), ''sinking'' at O'Leno State Park and ''rising'' at River Rise Preserve State Park. The lower and upper portions of the Santa Fe River are intermittently connected during high flow events. The riparian lands along stream reaches in this unit are generally privately owned agricultural or silvicultural lands, or State-owned or -managed conservation lands (Table 1). The Suwannee moccasinshell occupies all stream reaches in this unit, which contains most of the physical or biological features essential to the conservation of the Suwannee moccasinshell. However, decreases in stream flow and changes in water quality, especially increased nitrogen loads and algae growth, are recognized issues in all stream reaches within the unit (SRWMD 2017, pp. 26–27, 42–50). During drought, depressed dissolved oxygen levels and elevated water temperatures may also be degraded in some reaches. Therefore, physical or biological features 3 and 4 are not consistently present in the unit. Currently, 73 percent of Unit 1 is designated critical habitat for the Gulf sturgeon (a migratory fish). Some small urban areas also are located near the two rivers. Special management considerations and protections that may be required to address threats within the unit include: Minimizing ground and surface water withdrawals or other actions that alter stream hydrology; reducing the use of fertilizers and pesticides, especially in spring recharge areas and near stream channels; improving treatment of wastewater discharged from permitted facilities and the operation of those facilities; implementing practices that protect or restore riparian buffer areas along stream corridors; avoidance of physical alternations to the stream channel and floodplain; prohibiting the removal of pre-cut submerged timber (deadhead logs); and establishing and enforcing restrictions on boat speed and length, especially in the lower Santa Fe River. Many of these measures would also be implemented in stream reaches upstream of the unit to adequately protect habitat within the unit. For example, a large surface mining project is proposed adjacent the New River within the upper Santa Fe River watershed. If the mining operation and its associated structures are constructed as currently proposed, we anticipate that physical or biological features 3 and 4 would be negatively impacted to a significant degree within the unit. In addition, groundwater discharge via springs is important to maintaining flows and water quality needed by the species, especially during drought (Holcomb et al., 2018, p. 95). Therefore, spring recharge areas and aquifers may also need to be protected in order to fully address threats within the unit. Unit 2: Upper Santa Fe River, Florida Unit 2 consists of approximately 43 km (27 mi) of the Santa Fe River and New River in Alachua, Bradford, Columbia, and Union Counties, Florida. The unit includes the Santa Fe River from the river’s sink in Alachua County, upstream 36.5 km (23 mi) to the confluence of Rocky Creek in Bradford and Alachua Counties; and the New River from its confluence with the Santa Fe River, upstream 6.5 km (4 mi) to the confluence of Five Mile Creek in Union and Bradford Counties. The riparian lands along stream channels in this unit are generally privately owned agricultural or silvicultural lands, or are State-owned or -managed conservation lands (Table 1). All of Unit 2 is also designated critical habitat for the oval pigtoe (a freshwater mussel). The Suwannee moccasinshell was routinely represented in historical collections in the upper Santa Fe sub-basin; however, it is the only mussel species not detected in contemporary surveys. Unit 2 retains the features of a natural stream channel and presently supports a diverse mussel fauna, including several mussel species known to co-occur with the Suwannee moccasinshell. This unit has at least one of the physical or biological features essential to the conservation of the species, and we are reasonably certain that this area will contribute to the conservation of the species. Our specific rationale for this unit can be found below. This area is essential for the conservation of the species because it would improve its resiliency and redundancy of the species, which is necessary to conserve and recover the Suwanee moccasinshell. To improve the species’ overall viability by increasing resiliency and redundancy, it is important to reestablish Suwannee moccasinshell populations in its former range in the Santa Fe River sub-basin (i.e., Unit 2). Presently, nearly the entire population of the species is linearly distributed within the Suwannee River and vulnerable to catastrophic events (for example, contaminant spills or severe floods), as well as to random fluctuations in population size or environmental conditions (Haag and Williams 2014, p. 48). Therefore, reestablishing populations in Unit 2 would reduce its extinction risk by expanding its current range into areas beyond the mainstem by providing connectivity to already occupied areas, space for growth and population expansion in portions of historical habitat, and refugia areas from threats in the Suwannee River. Although it is considered unoccupied, portions of this unit contain some or all of the physical or biological features essential for the conservation of the species. Unit 2 possesses characteristics described by physical or biological features 1 and 2 as long reaches of stable stream channel and suitable substrates are present throughout much of the unit. Unit 2 retains the features of a natural stream channel and presently supports a diverse mussel fauna, including several mussel species that ordinarily co-occur with the Suwannee moccasinshell. Both fish species found to serve as larval hosts for the Suwannee moccasinshell occur within the unit (Robins et al., 2018, pp. 317, 336). Physical or biological features 3 and 4 are degraded in the Unit during some times of the year. Flow levels in the upper Santa Fe River have declined over time, and the river has ceased to flow multiple times since 2000 (Johnson et al., 2016, p. 170). An important effect of reduced flows is altered water quality, especially depressed dissolved oxygen levels and elevated water temperatures (discussed above under ‘‘Physical or Biological Features’’). In 2007, the District developed minimum flow levels to establish flows protective of ‘‘fish and wildlife habitats and the passage of fish’’ in the upper Santa Fe River (SRWMD 2007, entire). The restoration of natural flow levels is a complex issue that will require considerable involvement and collaboration of Federal, State, and local governments and private landowners to implement projects that reduce groundwater pumping in order to recover aquifer levels and sustain base flows in the upper Santa Fe River sub-basin. However, if implemented, water management strategies would improve physical or biological features 3 and 4. The need for conservation efforts is recognized by our conservation partners, and methods for restoring natural flow regimes and reintroducing the species into unoccupied habitat are being advocated and developed. Accordingly, we are reasonably certain this unit will contribute to the conservation of the species. Unit 3: Withlacoochee River, Georgia and Florida Unit 3 consists of approximately 75.5 km (47 mi) of the Withlacoochee River in Madison and Hamilton Counties, Florida, and Brooks and Lowndes Counties, Georgia. The unit includes the Withlacoochee River from its confluence with the Suwannee River in Madison and Hamilton Counties, FL, upstream 75.5 km (47 mi) to the confluence of Okapilco Creek in Brooks and Lowndes Counties, GA. The riparian lands along stream channels in this unit are generally privately owned agricultural or silvicultural lands (Table 1). Unit 3 is within the historical range of the Suwannee moccasinshell but is not currently occupied by the species. Twenty-five percent of Unit 3 is also designated critical habitat for the Gulf sturgeon. Unit 3 retains the features of a natural stream channel and supports a diverse mussel fauna, including several mussel species known to cooccur with the Suwannee moccasinshell. This unit has at least one of the physical or biological features essential to the conservation of the species and we are reasonably certain that this area will contribute to the conservation of the species. Our specific rationale for this unit can be found below. This area is essential for the conservation of the species because it would improve the resiliency and redundancy of the species, which is necessary to conserve and recover the Suwanee moccasinshell. Presently, nearly the entire population of the species is linearly distributed within the Suwannee River (see Unit 1 above) and vulnerable to catastrophic events (for example, contaminant spills or severe floods) as well as to random fluctuations in population size or environmental conditions (Haag and Williams 2014, p. 48). Reestablishing populations in Withlacoochee River sub-basin would reduce its extinction risk by expanding its current range into areas beyond the mainstem by providing connectivity to already occupied areas, space for growth and population expansion in portions of historical habitat, and refugia areas from threats in the Suwannee River. Although it is considered unoccupied, portions of this unit contain some or all of the physical or biological features essential for the conservation of the species. Specifically, Unit 3 possesses characteristics described by physical or biological features 1 and 2 as long reaches of stable stream channel with suitable substrates are present within the unit. Unit 3 retains the features of a natural stream channel and supports a diverse mussel fauna, including several mussel species that ordinarily co-occur with the Suwannee moccasinshell. Both fish species found to serve as larval hosts for the Suwannee moccasinshell occur within the unit (Robins et al. 2018, pp. 317, 336). Therefore, we find that the unit has the potential to support the species’ lifehistory functions. Physical or biological feature 4 is in degraded condition, and pollution may have contributed to the Suwannee moccasinshell’s decline in Unit 3. The domestic wastewater treatment plant for the city of Valdosta, GA is approximately 14 river miles upstream of the unit and has a history of untreated sewage releases to the Withlacoochee River after heavy rain events. However, major renovations to the city’s sewer system were completed in June 2016 with the construction of a new treatment plant. Additional projects to address continued problems with sewage spills are ongoing, and the construction of a large retention basin is planned. If these improvements are realized, water quality could be restored to levels necessary to support the species. The need for conservation efforts is recognized by our conservation partners, and methods for restoring and reintroducing the species into unoccupied habitat are being developed. The Florida Fish and Wildlife Conservation Commission and Georgia Department of Natural Resources have expressed support for including this area in a critical habitat designation (Florida Fish and Wildlife Conservation Commission 2019; Georgia Department of Natural Resources 2018). Accordingly, we are reasonably certain this unit will contribute to the conservation of the species. (USFWS, 2021)

Primary Constituent Elements/Physical or Biological Features

Summary of Essential Physical or Biological Features We have determined that the following physical or biological features are essential to the conservation of Suwannee moccasinshell: (1) Geomorphically stable stream channels (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation). (2) Stable substrates of muddy sand or mixtures of sand and gravel, and with little to no accumulation of unconsolidated sediments and low amounts of filamentous algae. (3) A natural hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species is found, and connectivity of stream channels with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes. (4) Water quality conditions needed to sustain healthy Suwannee moccasinshell populations, including low pollutant levels (not less than State criteria), a natural temperature regime, pH (between 6.0 to 8.5), adequate oxygen content (not less than State criteria), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages. (5) The presence of abundant fish hosts necessary for recruitment of the Suwannee moccasinshell. The presence of blackbanded darters (Percina nigrofasciata) and brown darters (Etheostoma edwini) will serve as an indication of fish host presence. (USFWS, 2021)

Special Management Considerations or Protections

ess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. All three units that we are designating as critical habitat, including the unit that was occupied by the species at the time of listing, have mixed ownership of adjacent riparian lands, with mainly private (72 percent) and State (27 percent) lands (Table 1). All Stateowned riparian lands are in Florida, and the majority are managed by Florida’s Suwannee River Water Management District (District). Tracts are managed to maintain adequate water supply and water quality for natural systems by preserving riparian habitats and restricting development (SRWMD 2014, p. 3). The District established minimum flows and levels for the lower Suwannee River, downstream of Fanning Springs and for the upper Santa Fe River. Minimum flow and level criteria establish a limit at which further withdrawals would be detrimental to water resources, taking into consideration fish and wildlife habitats, the passage of fish, sediment loads, and water quality, among others (SRWMD 2005, pp. 6–8; SRWMD 2007, entire). In addition, the Suwannee River and Santa Fe River systems have been designated Outstanding Florida Waters, which prevents the permitted discharge of pollutants that would lower existing water quality of, or significantly degrade, such waters. While these programs may indirectly alleviate some detrimental impacts on aquatic habitats, there currently are no plans or agreements designed specifically for the conservation of the Suwannee moccasinshell or for freshwater mussels in general. The features essential to the conservation of the Suwannee moccasinshell may require special management considerations or protection to ameliorate the following threats: Altered flow regimes, nonpoint source pollution (from stormwater runoff or infiltration), point source pollution (from wastewater discharges or accidental releases), physical alterations to the stream channel (for example, dredging, straightening, impounding, etc.), and altered physical and chemical water quality parameters (especially, temperature, dissolved oxygen, turbidity, pH, and salinity). Special management considerations or protection may be required within critical habitat areas to ameliorate these threats, and include (but are not limited to): (1) Moderation of surface and ground water withdrawals; (2) improvement of the treatment of wastewater discharged from permitted facilities and the operation of those facilities; (3) reductions in pesticide and fertilizer use especially in groundwater recharge areas and near stream channels; (4) use of best management practices designed to reduce sedimentation, erosion, and stream bank alteration; (5) protection and restoration of riparian buffers; and (6) avoidance of physical alterations to stream channels and adjacent floodplains. This list applies only to Federal actions (see the Application of the ''Adverse Modification'' Standard below for more information). (USFWS, 2021)

Life History

Feeding Narrative

Adult: Adult mussels obtain food items both from the water column and from the sediments. They filter feed by taking water in through the incurrent siphon and across four gills that are specialized for respiration and food collection. They can also move sediment material into the shell by using cilia (hair-like structures) on the foot or through currents created by cilia. Juvenile mussels typically burrow completely beneath the substrate surface for the first several months of their life. During this time, they feed primarily with their ciliated foot, which they sweep through the sediment to extract material, until the structures for filter feeding are more fully developed. Mussels feed on a variety of microscopic food particles that include algae, diatoms, bacteria, and fine detritus (disintegrated organic debris) (McMahon and Bogan 2001, p. 331; Strayer et al. 2004, pp. 430–431, Vaughn et al. 2008, p. 410) (USFWS, 2015).

Reproduction Narrative

Adult: Spawning in freshwater mussels generally occurs from spring to late summer (Haag 2012, p. 38). Water temperature appears to be the primary cue for spawning (McMahon and Bogan 2001, p. 343; Galbraith and Vaughn 2009, p. 42). During spawning, males release sperm into the water column, which females take in through their inhalant aperture during feeding. Fertilization takes place inside the gills, and females brood the fertilized eggs in modified portions of one or both pairs of gills until they develop into mature larvae called glochidia. An ongoing study has provided preliminary information about the reproductive biology of the Suwannee moccasinshell. Females were found gravid with mature glochidia from December to February, and also in late May/early June (Johnson 2015 unpub. data). In laboratory trials, Suwannee moccasinshell glochidia transformed primarily on the blackbanded darter (Percina nigrofasciata) and to a lesser extent on the brown darter (Etheostoma edwini) (Johnson 2015 unpub. data). Six other fish species from 5 families were also tested but none transformed moccasinshell larvae. This indicates that the Suwannee moccasinshell is a host specialist and dependent on darters for reproduction, and is consistent with other members of the genus Medionidus, which also use only darters (Percidae) as hosts (Haag and Warren 2003, p. 82; Fritts and Bringolf 2014, p. 54) (USFWS, 2015). This species is probably bradytictic (long-term brooder), as is its northern congener, Medionidus conradicus (NatureServe, 2015).

Geographic or Habitat Restraints or Barriers

Adult: Upland habitat, lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear - along bank margins (USFWS, 2015)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2015)

Habitat Narrative

Adult: The Suwannee moccasinshell typically inhabits larger streams where it is found in substrates of muddy sand or sand with some gravel, and in areas with slow to moderate current (Williams and Butler 1994, p. 86; Williams 2015, p. 2). Recent surveys by the Florida Fish and Wildlife Conservation Commission (FFWCC) for the species in the Suwannee River main channel found individuals at depths ranging from around 0.5 to 2.5 meters (1.6 to 8.2 ft.) (FFWCC 2014 unpub. data). Based on stream conditions in areas that still support the species, suitable Suwannee moccasinshell habitat appears to be clear stream reaches along bank margins with a moderate slope and stable sand substrates, where flow is moderate and slightly depositional conditions exist. In addition, the Suwannee moccasinshell is associated with large woody material, and individuals are often found near embedded logs (USFWS, 2015). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Very low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (USFWS, 2015)

Dispersal/Migration Narrative

Adult: Darters are small, bottom-dwelling fish that generally do not move considerable distances (Freeman 1995, pp. 363–365; Holt 2013, p. 657). Thus, the exclusive use of darters as a host may limit the Suwannee moccasinshell’s ability to disperse, and to recolonize some areas from which it has become extirpated (USFWS, 2015). Adults are essentially sessile however some passive movement downstream may occur during high flows (NatureServe, 2015).

Population Information and Trends

Population Trends:

70 - 90% decline (NatureServe, 2015)

Species Trends:

Declining (USFWS, 2022)

Number of Populations:

2 (inferred from USFWS, 2022)

Population Size:

69 collected 2013 - 2014 (USFWS, 2015)

Population Narrative:

Targeted surveys by FFWCC biologists in 2013 and 2014 show that Suwannee moccasinshell numbers are low. Experienced mussel biologists surveyed 96 sites, covering most of its historical range, and collected a total of 67 live individuals at 21 sites, all from the Suwannee River main channel. Two individuals were collected from at 2 sites in the New River (USFWS, 2015). This species is exceedingly rare and is in significant decline. It has experienced a long term population decline of 70 - 90% (NatureServe, 2015). The Suwannee Moccasinshell is a small freshwater mussel presently found only in the Suwannee River and in a short reach of the lower Santa Fe River in Florida. Since being listed as threatened in 2016, the species' distribution remains limited to approximately 160-kilometers (99-miles) of stream channel where fewer than ten live individuals have been observed. The decline of individuals in the lower Santa Fe River continues to be concerning for the species (USFWS, 2022).

Threats and Stressors

Stressor: Habitat degradation (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Habitat degradation is occurring throughout the entire range of the Suwannee moccasinshell and is due primarily to pollutants discharged from municipal and industrial facilities, polluted runoff from agricultural areas, and reduced flows as a result of groundwater pumping and drought. In portions of the species' range, sedimentation has also impacted the species' habitat. These threats are greater in the two tributary systems, as evidenced by the species' possible disappearance from the Withlacoochee River, and its dramatic decline in the Santa Fe River sub-basin. Currently, nearly the entire population resides in the middle and lower reach of the Suwannee River main channel. The two greatest threats to the species, pollutants and reduced flows, are somewhat attenuated in the main channel, where flows are generally sustained and pollutant concentrations may be diluted by higher flow volumes. While there are programs in place that may indirectly alleviate some detrimental impacts on aquatic habitats, there currently are no conservation efforts designed specifically to protect or recover Suwannee moccasinshell populations (USFWS, 2015).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2015)
Exposure:
Response:
Consequence:

Narrative: Despite existing authorities such as the Clean Water Act, pollutants continue to impair the water quality throughout the current range of the Suwannee moccasinshell. State and Federal regulatory mechanisms have helped reduce the negative effects of point source discharges since the 1970s, yet these regulations are difficult to implement and regulate. While new water quality criteria are being developed that take into account more sensitive aquatic species, most criteria currently do not (USFWS, 2015).

Stressor: Catastrophic weather events and climate change (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: The Gulf coastal region is prone to extreme hydrologic events. Extended droughts result from persistent high-pressure systems, which inhibit moisture from the Gulf of America from reaching the region (Jeffcoat et al. 1991, pp. 163–170). Warm, humid air from the Gulf of America can produce strong frontal systems and tropical storms resulting in heavy rainfall events that cause severe flooding (Jeffcoat et al. 1991, pp. 163–170). Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may exacerbate the decline of mussel populations suffering the effects of other threats. During high flows, flood scour can dislodge mussels (particularly juveniles) where they may be injured, buried, or swept into unsuitable habitats, or mussels may be stranded and perish when flood waters recede (Vannote and Minshall 1982, p. 4,105; Tucker 1996, p. 435; Hastie et al. 2001, pp. 107–115; Peterson et al. 2011, unpaginated). During drought, stream channels may be dewatered entirely, or become disconnected pools where mussels are exposed to higher water temperatures, lower dissolved oxygen levels, and predators. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin et al. 2002, p. 6,074; Golladay et al. 2004, p. 504; Cook et al. 2004, p. 1,015). Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in hydrologic and temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions (USFWS, 2015).

Stressor: Small population size (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: The Suwannee moccasinshell's reduced range and small population size may increase its vulnerability to many threats. Species with small ranges, few populations, and small or declining population sizes are the most vulnerable to extinction (Primack 2008, p. 137). The effects of certain environmental pressures, particularly habitat degradation and loss, catastrophic weather events, and introduced species, are greater when population size is small (Soule´ 1980, pp. 33, 71; Primack 2008, pp. 133–137, 152). Suwannee moccasinshell populations are small and declining and are vulnerable to habitat degradation, droughts, and competition from the introduced Asian clam. In addition, its current range is relatively small, consisting of a stream channel segment of about 103 miles in length (USFWS, 2015).

Stressor: Nonnative species (USFWS, 2015)
Exposure:
Response:
Consequence:

Narrative: The Asian clam (Corbicula fluminea) was first detected in eastern Gulf drainages in the early 1960s and is presently widespread in the Suwannee River Basin. Anecdotal observations suggest that, when the Asian clam became established in other Gulf coast drainages, native mussel abundance declined drastically (Heard 1975, p. 2; Shelton 1995, p. 4). Mechanisms by which the Asian clam may negatively affect mussels include as a competitor for food and space; by ingesting mussel sperm, glochidia, and newly metamorphosed juveniles; and by displacing newly metamorphosed mussels from the substrate, causing them to be washed downstream (Neves and Widlak 1987, p. 6; Leff et al. 1990, p. 415; Strayer 1999, p. 82; Yeager et al. 2000, pp. 255–257). The flathead catfish (Pylodictis olivaris) has been introduced to the Suwannee River Basin and may be adversely impacting native fish populations. The flathead catfish is a large predator native to the central United States, and since its introduction outside its native range, it has altered the composition of native fish populations through predation (Boschung and Mayden 2004, p. 350). One study in the Flint River system in Georgia found that young-of-the-year flatheads consumed several fish species including darters (Etheostoma spp.) (Quinn 1988, p. 88). The loss or reduction of darters, which are essential during the moccasinshell's parasitic larval stage, would affect the Suwannee moccasinshell's ability to recruit and disperse (USFWS, 2015).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 11

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.
- Florida's Suwannee River Water Management District (SRWMD) owns, manages, or co-manages a significant portion of the basin's riparian lands (more than 48,000 acres, CBI 2010) adjacent to or upstream of Suwannee moccasinshell habitats. Tracts are managed to maintain adequate water supply and water quality for natural systems by preserving riparian habitats and restricting development (SRWMD 2014, p. 3). The SRWMD also established minimum flows and levels for the river channel in the lower basin, downstream of Fanning Springs. Minimum flow and level criteria were not designed with specific consideration for freshwater mussels, but do establish a limit at which further withdrawals would be detrimental to water resources, taking into consideration fish and wildlife habitats, the passage of fish, sediment loads, and water quality, among others (SRWMD 2005, pp. 6–8) (USFWS, 2015).

Conservation Measures and Best Management Practices:
- RECOMMENDED FUTURE ACTIVITIES This species does not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities which are included below. Recovery Activities a) Use regulatory means and advocacy to initiate actions that protect aquatic resources in the Suwanee River basin, including but not limited to: • minimizing ground and surface water withdrawals or other actions that alter stream hydrology; • improving ground water recharge or preventing action that would decrease groundwater recharge, such as

large changes in land use; • reducing the use of fertilizers and pesticides, especially in spring recharge areas and near stream channels; • improving treatment of wastewater discharged from permitted facilities and the operation of those facilities; • implementing practices that protect or restore riparian buffer areas along stream corridors, avoid physical alternations to the stream channel and floodplain, and ensure continued connection between the two; • prohibiting the removal of pre-cut submerged timber (deadhead logs); and • establishing and enforcing restrictions on boat speed and length, especially in the lower Santa Fe River. b) Develop captive propagation and reintroduction plan for the Suwannee River basin in cooperation with State partners. c) Initiate actions to restore stream connectivity and increase in-stream habitat. Actions include, but are not limited to, an assessment of all road crossings and replacing those that present a barrier to transit by aquatic organisms, bank stabilization, and riparian buffer maintenance or augmentation. d) Develop programs and outreach materials to increase public awareness of the species and explain the benefits of protecting stream ecosystems, including through the use of conservation easements. Monitoring and Research Activities e) Determine life history, reproductive biology, fecundity, sizes and viabilities of extant populations, and microhabitat requirements, as well as sensitivity to silt, excessive nutrients, and pollutants. All partners should be aware of research efforts and results to facilitate the immediate application of results. f) Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and population genetic structure, and establish genetic management plans. g) Determine flow requirements for each life-stage. h) Use eDNA as a detection tool to provide up-to-date distributional information. Use assays to confirm presence in historical reaches and detect previously unknown populations. i) Conduct status surveys in the Withlacoochee River in Florida and Georgia and lower Santa Fe River in Florida and document habitat conditions. j) Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. k) Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, age-specific survival, and monitor changes through time. l) Examine the population status of host fishes (e.g., Percina spp. and Etheostoma spp.) and identify factors potentially inhibiting host-mussel interactions. m) Conduct long-term monitoring studies of stream thermal regimes, especially during summer low flow conditions. n) Establish and maintain long-term salinity monitoring stations in the lower Suwannee River to better evaluate seasonal changes and impacts related to storm events, droughts, flooding, sealevel rise, and freshwater withdrawals. o) Model future precipitation, temperature, and flow scenarios in the Suwannee River basin to examine the impacts of climate change and consumptive uses. p) Model predicted climate related impacts of concern, including saltwater intrusion into freshwater wetlands in the lower Suwannee River system as a result of multiple factors including sea-level rise, altered hydrologic regimes, and increased water withdrawals (USFWS, 2022).

References

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: September 20, 2016)

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/ecp0/. Accessed August 2016

USFWS 2015. Endangered and Threatened Wildlife and Plants

Proposed Threatened Species Status for the Suwannee Moccasinshell. 80 Federal Register 193. October 6, 2015. Pages 60335 - 60348. USFWS. 2022. Suwannee Moccasinshell (Medionidus walkeri) Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 13 pp.

USFWS. 2021. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Suwannee Moccasinshell. Final Rule. FR Vol. 86, No. 124. Pages 34979-34998.

Proposed Threatened Species Status for the Suwannee Moccasinshell. 80 Federal Register 193. October 6, 2015. Pages 60335 - 60348

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: September 20, 2016) USFWS. 2022. Suwannee Moccasinshell (Medionidus walkeri) Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 13 pp.

USFWS. 2015. Endangered and Threatened Wildlife and Plants

Proposed Threatened Species Status for the Suwannee Moccasinshell. 80 Federal Register 193. October 6, 2015. Pages 60335 - 60348.

USFWS. 2022. Suwannee Moccasinshell (Medionidus walkeri) Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 13 pp.

SPECIES ACCOUNT: *Obovaria retusa* (Ring pink (mussel))

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 09/29/1989, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

The ring pink mussel is a freshwater mussel with a round (ovate) shell that is yellowish-green to brown in younger individuals that darkens with age. It is a medium to large mussel with an inflated, solid shell that is ovate to subquadrate in outline. The ventral and posterior shell margins are regularly rounded. The beaks are swollen and high, and are turned forward over a well-defined lunule. Beak sculpture consists of a few weak double-looped ridges. The posterior ridge in the female shell is more distinct, and the marsupial area is slightly more inflated than in the male shell. The shell surface is marked by low, irregular, concentric growth lines. The epidermis is cloth-like, rayless, and yellowish-green to brown in color with older individuals usually darker brown to black (Simpson, 1914; LaRocque, 1967; Parmalee, 1967).

Taxonomy

Not Available

Historical Range

Historically, the ring pink mussel was widespread in mid-size to large rivers in the Ohio River basin. It is now one of the rarest mussels in North America and is on the brink of extinction. Collections and observations during the last 30 years have yielded only about 18 records of the ring pink from the Tennessee, Cumberland, and Green Rivers. At the time the recovery plan was completed in 1991, it was believed that five populations remained; however, even these populations were considered to be relic and possibly non-reproducing (USFWS 1991). These populations were located within four river basins: the Green River in Kentucky, the Kanawha River in West Virginia, and the Tennessee and Cumberland rivers in Kentucky and Tennessee. The record from the Kanawha River in West Virginia has since been confirmed as a misidentification (William Tolin, October 24, 1991 memorandum), and the species is now considered to be extirpated from West Virginia.

Current Range

This species continues to be extremely rare and no individuals were observed over the past year (USFWS 2011). Over the past 10 years, the only live individuals (total of 3) have been observed in the Green River (Kentucky). The most significant threats identified in the recovery plan (conversion of free-flowing rivers to impoundments; decreased availability of fish host(s); sedimentation of habitat from channel dredging and gravel mining) continue to impact the species and no viable populations of the species are believed to exist. Intensive survey efforts by KDFWR and Campbellsville University (Dr. Richie Kessler) on the Green River (Green and Hart Cos, KY) in FY10 did not locate individuals of O. retusa. The fish host remains unknown.

Critical Habitat Designated

No;

Life History

Reproduction Narrative

Adult: Gravid females have been found with eggs in late August and with glochidia in September (Ortmann, 1909; 1912). The glochidial host fish for the species is unknown. Habitat – The species inhabits freshwater. Although characterized as preferring large rivers, it has been reported from the Duck River, indicating it can tolerate medium rivers (Mirarchi et al., 2004). Gravel and sand bars are preferred (Neel and Allen, 1964; Hickman, 1937). Because of reservoir construction on these large rivers, most historic occurrences have been inundated (Bogan and Parmalee, 1983).

Habitat Narrative

Adult: Although characterized as preferring large rivers, it has been reported from the Duck River, indicating it can tolerate medium rivers (Mirarchi et al., 2004). Gravel and sand bars are preferred (Neel and Allen, 1964; Hickman, 1937). Because of reservoir construction on these large rivers, most historic occurrences have been inundated (Bogan and Parmalee, 1983).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Narrative:

It appears that no viable populations remain for this species in the Ohio River basin. At the time the recovery plan was completed in 1991, five populations were known; however, even these populations were considered to be relic and possibly non-reproducing. Threats to the remaining populations identified in the recovery plan included water quality problems due to oil and gas production, gravel dredging, channel maintenance, commercial mussel fishing, and reduced natural reproduction. The record from the Kanawha River in West Virginia has since been determined to be a misidentification (Tolin 1991); therefore, this species is considered extirpated from West Virginia. Records from the Tennessee River are 25 years old or more (Leroy Koch 2007; Don Hubbs 2017). The most-recent record from the Tennessee River downstream of Wilson Dam is from the early 1990s due to a commercial mussel harvest (Richardson 2005). The species likely has been extirpated from all but the following five river reaches: the Green River in Kentucky, the Tennessee River downstream of Wilson Dam in Alabama, the Tennessee River downstream of Pickwick Landing Dam in Tennessee, portions of the Cumberland River, and the Tennessee River downstream of Kentucky Dam in Kentucky. The most recent records are from the Green River, where four live adults have been found since 1998. We believe the species still exists in the Green River, but in extremely low numbers that hamper detection efforts. It may occur in other river systems, but the likelihood of detecting this species is extremely low. Ring Pink mussels are rare and occur in such low densities that they are unlikely to be detected during typical mussel surveys, which are often of limited scope and duration. They are also a relatively longlived mussel species, so a population may persist for many decades, which can provide future opportunities to locate individuals. These factors, combined with the recent progress in mussel in-vitro culture methods, suggest that numerous juvenile Ring Pinks could be produced for recovery efforts from only one or a few gravid females, if those females can be found. (USFWS, 2019)

Threats and Stressors

Stressor: Habitat loss
Exposure:
Response:
Consequence:
Narrative: Threats for the species remain very similar to those present when the recovery plan was developed. Current threats to the ring pink primarily result from its restricted range, small population numbers, and its apparent inability or limited ability to recruit individuals into the population. In addition, the conversion of sections of large rivers from free-flowing systems to a series of long, linear impoundments has seriously reduced the availability of its preferred riverine gravel and sand habitat and likely affected the distribution and availability of the ring pink mussel's fish host.

Recovery

Recovery Actions:

- Maintaining high quality habitat, consisting of flowing water regions of large rivers with good water quality.
- Initiating a program of artificial propagation to insure survival of the species.
- Determining the ecological requirements of the species, including its fish host.
- Monitoring and regulating land use in the watershed to prevent siltation to rivers. Most areas of historical occurrences cannot be restored because of river modifications. Only a few former habitats are available for reintroduction. Water quality may require upgrading in these locations, and any reintroductions would probably involve artificial propagation of the species.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Since we have had limited success in finding individuals, we believe the following actions, in priority order, should be our direction for the next 5 years: 1. Conduct thorough surveys of the Green River in areas with suitable habitat from Green River Lake Dam downstream to Green River Lock and Dam 4. Individuals found should be pit tagged and located in areas of suitable habitat, where they can be accessed for life history study and propagation efforts. 2. Conduct thorough surveys for the Ring Pink in the Tennessee and Cumberland Rivers at sites with suitable habitat and mussel assemblages indicating the possible presence of this species. 3. Determine the fish host(s) of the Ring Pink and propagate the species using the fish host and/or in-vitro methods. Any propagated juveniles should be translocated to areas with suitable habitat in the Green River and/or other suitable streams within the species' historic range. 4. Begin studies in the cryopreservation of gametes and glochidia of a surrogate mussel in anticipation of using this technique on the Ring Pink. This work, if successful, will preserve gametes and glochidia for propagation. This is needed because of the difficulty of bringing male and female Ring Pink mussels together for reproduction. 5. Solicit the assistance of commercial mussel fishermen to help find live Ring Pinks and make them available for propagation purposes. 6. Update the recovery plan as new information is obtained with regard to the species' status. 7. Seek funding to continue survey efforts for the Ring Pink. Mussel surveys for this species often require divers, which results in a higher survey costs. (USFWS, 2019)

References

USFWS 2016. Status of the Species and Critical Habitat: Obovaria retusa (Ring pink mussel). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS 2016. Status of the Species and Critical Habitat: Obovaria retusa (Ring pink mussel). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016. USFWS. 2019. Ring Pink Obovaria retusa (Lamarck, 1819) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Kentucky Ecological Services Field Office Frankfort, Kentucky. 13 pp.

USFWS. 2019. Ring Pink Obovaria retusa (Lamarck, 1819) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Kentucky Ecological Services Field Office Frankfort, Kentucky. 13 pp.

SPECIES ACCOUNT: *Obovaria subrotunda* (Round hickorynut)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

Round Hickorynut adult mussels are greenish-olive to dark or chestnut brown, sometimes blackish in older individuals, and may have a yellowish band dorsally (Parmalee and Bogan 1998, p. 168). There is variability in the inflation of the shell depending on population and latitudinal location (Ortmann 1920, p. 272; Williams et al. 2008, p. 474). The shell is thick, solid, and up to 3 inches (in) (75 millimeters (mm) in length, but usually is less than 2.4 in. (60 mm) (Williams et al. 2008, p. 473; Watters et al. 2009, p. 209). A distinctive characteristic is that the shell is round in shape, nearly circular, and the umbo (the raised portion of the dorsal margin of a shell), is centrally located (Figure 1-1) (USFWS, 2019)

Taxonomy

The Round Hickorynut mussel belongs to the family Unionidae, also known as the naiads or pearly mussels. This group of bivalves has existed for over 400 million years (Howells et al. 1996, p. 1), representing over 600 species worldwide and over 250 species in North America (Strayer et al. 2004, p. 429; Lopes-Lima et al. 2018, p. 3). This Round Hickorynut SSA report follows the most recently published and accepted taxonomic treatment of North American freshwater mussel as provided by Williams et al. (2017, entire). The Round Hickorynut, Obovaria subrotunda (Rafinesque, 1820), was originally described under in the genus Obliquaria (and later moved to Obovaria) and subgenus Rotundaria (which is no longer recognized). Vanatta (1915, p. 552) identified the type collection at the Academy of Natural Sciences of Philadelphia, [ANSP] 20254, as having been part of the Rafinesque collection, and Johnson and Baker (1973, p. 171) designated that shell the neotype. The neotype is from the Kentucky River, Kentucky, which makes that the type locality. The currently accepted classification is: ● Phylum: Mollusca ● Class: Bivalvia ● Order: Unionoida ● Family: Unionidae ● Subfamily: Lampsilinae ● Tribe: Lampsilini ● Genus: Obovaria ● Species: subrotunda The synonymy for Obovaria subrotunda is extensive, possibly due to the species' display of clinal variation, ranging from a smaller 'compressed headwater form' to a more 'inflated big river' form. The Round Hickorynut is an example of a mussel used to describe this law of stream position (Ortmann 1920, p. 272). Additionally, other species (i.e., O. circulus, O. leibii), and subspecies (i.e., O. s. lens), have been referred to in the literature. However, O. subrotunda is currently the nomenclature collectively referring to all of these forms. (USFWS, 2019)

Historical Range

The historical range of the Round Hickorynut included streams and rivers across 12 states, including New York, Pennsylvania, West Virginia, Indiana, Illinois, Ohio, Kentucky, Virginia, Tennessee, Georgia, North Carolina, and Alabama. This range encompassed five major basins: the Great Lakes, Ohio, Cumberland, Tennessee, and Lower Mississippi. The best available information suggests that at least 295 populations and 137 MUs occurred over this range in the U.S.; however, it is also likely that more populations were present and undetected, prior to the use of more intensive contemporary survey methods (USFWS, 2022).

Current Range

The current range extends over nine states; the species is considered extirpated in Georgia, Illinois, and New York. This range encompasses five majorriver basins. Round Hickorynut representation in the Cumberland River basin is restricted to two linear populations within two MUs, while it exists in the Lower Mississippi River basin in a single population. Therefore, while the species currently maintains representation from historical conditions, it is at immediate risk of losing 40 percent (2 of 5 basins) representation due to these small, isolated populations under a high degree of threats that have resulted in habitat loss and water quality degradation. (USFWS, 2019)

Critical Habitat Designated

Yes; 4/10/2023.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine threatened species status under the Endangered Species Act of 1973 (Act), as amended, for the longsolid (Fusconaia subrotunda) and round hickorynut (Obovaria subrotunda), freshwater mussels. We also designate critical habitat for both species. For the longsolid, in total, approximately 1,115 river miles (1,794 river kilometers) fall within 12 units of critical habitat in Pennsylvania, Kentucky, West Virginia, Virginia, Tennessee, and Alabama. For the round hickorynut, in total, approximately 921 river miles (1,482 river kilometers) fall within 14 units of critical habitat in Pennsylvania, Ohio, Indiana, Kentucky, West Virginia, Tennessee, Alabama, and Mississippi.

Critical Habitat Designation

Critical habitat units for the round hickorynut are depicted on the maps in this entry for Jackson, Madison, and Marshall Counties, Alabama; Fulton, Marshall, Pulaski, and Starke Counties, Indiana; Bath, Butler, Campbell, Edmonson, Fleming, Green, Harrison, Hart, Kenton, Laurel, Morgan, Nicholas, Pendleton, Pulaski, Rockcastle, Robertson, Rowan, and Warren Counties, Kentucky; Montgomery County, Mississippi; Bedford, Marshall, and Maury Counties, Tennessee; Ashtabula, Lake, and Trumbull Counties, Ohio; Crawford and Mercer Counties, Pennsylvania; and Braxton, Calhoun, Clay, Doddridge, Fayette, Gilmer, Kanawha, Pleasants, Ritchie, Tyler, and Wood Counties, West Virginia.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of the round hickorynut consist of the following components:

(i) Adequate flows, or a hydrologic flow regime (magnitude, timing, frequency, duration, rate of change, and overall seasonality of discharge over time), necessary to maintain benthic habitats where the species is found and to maintain stream connectivity, specifically providing for the exchange of nutrients and sediment for maintenance of the mussel’s and fish host’s habitat and food availability, maintenance of spawning habitat for native fishes, and the ability for newly transformed juveniles to settle and become established in their habitats. Adequate flows ensure delivery of oxygen, enable reproduction, deliver food to filter-feeding mussels, and reduce contaminants and fine sediments from interstitial spaces. Stream velocity is not static over time, and variations may be attributed to seasonal changes (with higher flows in winter/spring and lower flows in summer/fall), extreme weather events (e.g., drought or floods), or anthropogenic influence (e.g., flow regulation via impoundments).

(ii) Suitable substrates and connected instream habitats, characterized by geomorphically stable stream channels and banks (i.e., channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with habitats that support a diversity of freshwater mussel and native fish (such as, stable riffle-runpool habitats that provide flow refuges consisting of predominantly silt-free, stable sand, gravel, and cobble substrates).

(iii) Water and sediment quality necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages, including (but not limited to): Dissolved oxygen (generally above 2 to 3 parts per million (ppm)), salinity (generally below 2 to 4 ppm), and temperature (generally below 86 °F (°F) (30 °Celsius (°C)). Additionally, water and sediment should be low in ammonia (generally below 0.5 ppm total ammonia-nitrogen) and heavy metal concentrations, and lack excessive total suspended solids and other pollutants.

(iv) The presence and abundance of fish hosts necessary for recruitment of the round hickorynut (i.e., eastern sand darter (Ammocrypta pellucida), emerald darter (Etheostoma baileyi), greenside darter (E. blennioides), Iowa darter (E. exile), fantail darter (E. flabellare), Cumberland darter (E. susanae), spangled darter (E. obama), variegate darter (E. variatum), blackside darter (Percina maculata), frecklebelly darter (P. stictogaster), and banded sculpin (Cottus carolinae)).

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the longsolid and round hickorynut may require special management considerations or protections to reduce the following threats: (1) Alteration of the natural flow regime (modifying the natural hydrograph and seasonal flows), including water withdrawals, resulting in flow reduction and available water quantity; (2) urbanization of the landscape, including (but not limited to) land conversion for urban and commercial use, infrastructure (pipelines, roads, bridges, utilities), and urban water uses (resource extraction activities, water supply reservoirs, wastewater treatment, etc.); (3) significant alteration of water quality and nutrient pollution from a variety of activities, such as mining and agricultural activities; (4) impacts from invasive species; (5) land use activities that remove large areas of forested wetlands and riparian systems; (6) culvert and pipe installation that creates barriers to movement for the longsolid and round hickorynut, or their host fishes; (7) changes and shifts in seasonal precipitation patterns as a result of climate change; and (8) other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. Managem

Life History

Food/Nutrient Resources

Food Source

Adult: A mixture of algae, bacteria, detritus, and microscopic animals (USFWS, 2019)

Lifespan

Adult: Max: Males 16 yrs; Females 13 yrs (USFWS, 2019)

Dependency on Other Individuals or Species

Adult: Host fish (Darters and others) (USFWS, 2019)

Breeding Season

Adult: Conglutinates appear to be formed only near the end of the brooding cycle and released in late spring or early summer, or even as late as August in southern populations, and most females synchronously expel their broods (USFWS, 2019).

Other Reproductive Information

Adult: Availability of sufficient host fish numbers to provide for glochidia infestation and dispersal. Host fish species include, but may not be limited to, darters of the family Percidae and genera Ammocrypta, Etheostoma, and Percina, as well as sculpins of the genus Cottus (USFWS, 2019).

Reproduction Narrative

Adult: Round Hickorynut reached sexual maturity (i.e., change in shell growth) in 3 to 5 years, with males living up to 16 years and females up to 13 years in Buck Creek, Kentucky, within the Cumberland basin (Shepard 2006, p. 16; Figure 3-2b). In comparison, the species reached sexual maturity at 1 year in the Duck River, Tennessee, and maximum age was 14 for males and 13 for females ([n = 100 individuals] Ehlo and Layzer 2014, p. 8; Figure 3-2c). Additional information from the Ohio and Great Lakes basins indicate “few individuals live longer than 12 years” (Watters et al. 2009, pp. 210–211). Overall, longevity and age-at-maturity data from 4 of the 5 basins (Great Lakes, Ohio, Cumberland, and Tennessee) where the species occurs suggests the maximum life span of Round Hickorynut is between 10 and 16 years (avg. 12 to 13), and the species reaches sexual maturity between 1 to 5 years (avg. 2 to 3). (USFWS, 2019) The species is sexually dimorphic, with character traits visible to differentiate individuals within 1–5 years, and males average slightly longer maximum ages (up to 16 years) (Shepard 2006, p. 7; Watters et al. 2009, p. 211; Ehlo and Layzer 2014, p. 11). Differences in shells are not pronounced, but in females the posterior margin of the shell is truncated, and females are generally smaller than males (Ortmann 1920, p. 307; Ehlo and Layzer 2014, p. 1) (USFWS, 2019). The Round Hickorynut has a complex life cycle (see Figure 3-3) that relies on fish hosts for successful reproduction, similar to other mussels. In general, mussels are either male or female (Haag 2012, p. 54). Males release sperm into the water column, which is taken in by the female through the incurrent aperture, where water enters the mantle cavity. The sperm fertilize eggs in the suprabranchial chamber (located above the gills) as ova are passed from the gonad to the marsupia (Yokely 1972, p. 357). The developing larvae remain in the gill chamber until they mature (called glochidia) and are ready for release. The Round Hickorynut is a long-term brooder, gravid year-round in some southern populations in the Tennessee River basin, but with gravid period potentially more contracted in the northernmost portions of its range. For example, in the Great Lakes basin, the species has been found gravid from September through the following June (Clarke 1981, p. 326; Gordon and Layzer 1989, p. 51). An orange-brown coloration has been observed on the outer edge of the mantle during gravidity, which appears slightly lamellar and crenulated in the Round Hickorynut (Ortmann 1911, p. 315; Shepard 2006, p. 15). Age and size affect fecundity, and while length is positively related to fecundity in other mussels, overall size (shell length, width, and height), is important for this relatively small species (Haag and Staton 2003, p. 2,118; Ehlo and Layzer 2014, p. 11). Localized habitat and environmental conditions are also a factor in fecundity of individuals (Moles and Layzer 2008, p. 220). The number of glochidia extracted from one female Round Hickorynut used during fish/host infestation trials was approximately 5,725 from Buck Creek in the Cumberland River basin (Shepard 2006, p. 15). Mean fecundity was estimated as 5,366 +/- 1,843 per female, as reported from three females examined in Lake St. Clair, Canada. Juveniles reached metamorphosis and dropped off host fishes within 4 to 40 days (McNichols 2007, p. 51). Fecundity did not vary in left versus right gills, and mean fecundity estimates were much higher in the Tennessee River basin: 36,101 and ranged from 7,122 to 76,584 (n = 30; Duck River; Ehlo and Layzer 2014, p. 171). Only a few glochidia reach the free-living juvenile stage, and mortality rates for the glochidial stage have been estimated at 99 percent, making this a critical phase in the life history of freshwater mussels (Jansen et al. 2001, p. 211). (USFWS, 2019)

Habitat Type

Adult: Freshwater/benthic

Habitat Vegetation or Surface Water Classification

Adult: Riverine

Dependencies on Specific Environmental Elements

Adult: Need clean, flowing water (USFWS, 2019)

Spatial Arrangements of the Population

Adult: Non-linear (USFWS, 2019.

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2019)

Site Fidelity

Adult: High (inferred from USFWS, 2019)

Habitat Narrative

Adult: Generally speaking, Round Hickorynut habitat is in rivers and streams with natural flow regimes. While mussels can survive seasonally low flows and (random) short-term, periodic drying events, intermittent stream habitats generally cannot support mussel populations. Because a lotic (i.e., flowing water) environment is a critical need for the Round Hickorynut, perturbations that disrupt natural flow patterns (e.g., dams) may negatively influence Round Hickorynut resilience metrics. Round Hickorynut habitat must have adequate flow to deliver oxygen, enable passive reproduction, and deliver food to filter-feeding mussels (see Table 4-1, above). Further, flowing water reduces contaminants and fine sediments from interstitial spaces, preventing mussel suffocation. Mussels may also shift to deposit feeding, underlying the importance of clean-swept substrates and interstitial spaces. Stream velocity is not static over time, and variations may be attributed to seasonal changes (with higher flows in winter/spring and lower flows in summer/fall), extreme weather events (e.g., drought or floods), or anthropogenic influence (e.g., flow regulation via impoundments). The Round Hickorynut relies on sight-feeding fishes as part of its life cycle; therefore, turbidity and high levels of suspended solids during critical reproductive periods may impact glochidial attachment and ultimately decrease recruitment in any given population (USFWS, 2019).

Dispersal/Migration

Dispersal

Adult: Dispersal is dependent on host fish and host fish movement is limited by impoundments (dams) and large stretches of unsuitable habitat (USFWS, 2019).

Dispersal/Migration Narrative

Adult: The species' capability to move and disperse is acknowledged as glochidia attach to fish, but the distance that adults are capable of dispersing within appropriate habitats or response to varying water levels, is unknown, but apparently very limited (USFWS, 2019)..

Additional Life History Information

Adult: All extant populations of Round Hickorynut are affected to some extent by impoundments, which isolate populations and prevent upstream dispersal (see section 6.1.5). However, tributaries that maintain connectivity to river reaches without large flood control, water supply, or hydropower dam interruption are comparatively less affected. Examples include Mill Creek (tributary to the Grand River) and the Red Bird River (tributary to the South Fork Kentucky River). Although smaller impoundments (mill dams) still occur in these watersheds, there is probable gene flow between these tributaries and mainstem rivers (USFWS, 2019).

Population Information and Trends

Population Trends:

Decreasing (inferred from USFWS, 2019)

Population Growth Rate:

Declining (USFWS, 2019.

Number of Populations:

69 extant? (USFWS, 2019)

Additional Population-level Information:

Estimates of current and future resiliency for the Round Hickorynut (Table 8-1, below) are low given that 4 of 69 populations and 2 of 36 MUs are estimated to be highly resilient (6 percent). Only 16 populations (25 percent) and 12 MUs (33 percent) are estimated to be moderately resilient. The remaining 49 populations (71 percent) and 22 MUs (61 percent) are in low condition and have limited resiliency. Seventy-seven percent (232) of the known populations of the species (301) are considered extirpated (USFWS, 2019).

Population Narrative:

Overall, the round hickorynut has lost an approximate 232 of 297 known populations (78 percent), and 104 of 138 management units (75 percent). This includes 25 populations in the Great Lakes basin, 150 populations in the Ohio River basin, 23 populations in the Cumberland River basin, 29 populations in the Tennessee River basin, and 9 populations in the Lower Mississippi River basin (see Appendix B in the SSA report (Service 2019, pp. 191–212)). Of the current populations, 4 (6 percent) are estimated to be highly resilient, 16 (23 percent) are estimated to be moderately resilient, and 45 (69 percent) are estimated to have low resiliency. The round hickorynut was once a much more common, occasionally abundant, component of the mussel assemblage in rivers and streams across much of the eastern United States. Population extirpations have been extensive and widespread within every major river basin where the round hickorynut is found. Surveys throughout eastern North America have not targeted the round hickorynut specifically, and as a result, there could have been additional population losses or declines that have gone undocumented. Conversely, it is possible that there are populations that have gone undetected. However, the majority of the species' range has been relatively well-surveyed for freshwater mussel communities, and the likelihood is small that there are substantial or stronghold populations that are undetected. Patterns of population extirpation and declines are pronounced particularly in the Ohio River basin, which appears to be the basin most important for redundancy and representation for the species, due to its documented historical distribution and remaining concentration of populations within the basin. (USFWS, 2019)

Threats and Stressors

Stressor: Development/Urbanization
Exposure:
Response:
Consequence:
Narrative: The term "development" refers to urbanization of the landscape, including (but not limited to) land conversion for residential, commercial, and industrial uses and the accompanying infrastructure. The effects of urbanization may include alterations to water quality, water quantity, and habitat (both in-stream and streamside)

Stressor: Transportation
Exposure:
Response:
Consequence:
Narrative: A major aspect of urbanization is the resultant road development. Road development requires land clearing and increases impervious surfaces as well as habitat fragmentation. Roads are generally associated with negative effects on the biotic integrity of aquatic ecosystems, including changes in surface water temperatures and patterns of runoff, changes in sedimentation levels, and increased heavy metals (especially lead), salts, organics, and nutrients to stream systems (Trombulak and Frissell 2000, p. 18). Maintenance of road corridors includes the use of herbicides and the application of chemicals to increase the longevity of the road surfaces. The adding of salts through road de-icing results in high salinity runoff, which is toxic to freshwater mussels. In addition, a major impact of road development is improperly constructed culverts at stream crossings. These culverts act as barriers if flow through the culvert varies significantly from the rest of the stream, or if the culvert ends up being perched, and aquatic organisms, specifically mussel host fishes, cannot pass through them. Improperly installed culverts alter in-stream habitat, and can cause changes in stream depth, resulting in pools upstream and a destabilized channel downstream of the culvert.

Stressor: Contaminants
Exposure:
Response:
Consequence:

Narrative: Contaminants contained in point and non-point discharges can degrade water and substrate quality and adversely impact mussel populations. Although chemical spills and other point sources of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result in part from the subtle, pervasive effects of chronic, low-level contamination (Naimo 1995, p. 354). The effects of heavy metals, ammonia, and other contaminants on freshwater mussels were reviewed by Mellinger (1972), Fuller (1974), Havlik and Marking (1987), Naimo (1995), Keller and Lydy (1997), and Newton et al. (2003). The effects of contaminants from metals, chlorine, and ammonia are profound on juvenile mussels (Augspurger et al. 2003, p. 2,571; Bartsch et al. 2003, p. 2,566). Juvenile mussels may readily ingest contaminants adsorbed to sediment particles while pedal feeding (Newton and Cope 2007, p. 276). These contaminants also affect mussel glochidia, which are sensitive to some toxicants; this has been displayed on the Clinch River, where the Round Hickorynut is currently considered extirpated, but it formerly occurred in the Tennessee section of the river (Goudreau et al. 1993, p. 221; Jacobson et al. 1997, p. 2,386; Valenti et al. 2005, p. 1,243). The effects of ammonia on mussels may be aggravated in the future due to the expected effects of climate change, in part due to human population growth and increased concentrations associated with point source discharges.

Stressor: Nutrient Pollution (Agricultural Activities)
Exposure:
Response:
Consequence:
Narrative: Farming operations, including concentrated animal feeding operations, can contribute to nutrient pollution when not properly managed (EPA 2016, entire). Fertilizers and animal manure, which are both rich in nitrogen and phosphorus, are the primary sources of nutrient pollution from agricultural sources. If fertilizers are not applied properly, at the right time of the year and with the right application method, water quality in the stream systems can be affected. Excess nutrients affect water quality when it rains or when water and soil containing nitrogen and phosphorus wash into nearby waters or leach into groundwater. Excess nitrogen and phosphorus may cause algal blooms in surface waters (Carpenter et al. 1998, entire). Fertilized soils and livestock can be significant sources of nitrogen-based compounds like ammonia and nitrogen oxides (Carpenter et al. 1998, entire). Ammonia can be harmful to aquatic life if large amounts are deposited to surface waters (see section 6.1.3, Contaminants, above). The lack of stable stream bank slopes from agricultural clearing or the lack of stable cover crops between rotations on farmed lands can increase the amount of nutrients that enter nearby streams by way of increased soil erosion (cover crops and other vegetation will use excess nutrients and increase soil stability) (Barling and Moore 1994, p. 543). Livestock often use streams or artificial in-line ponds as a water source, which degrades water quality and stream bank stability and reduces water quantity available for aquatic fauna, like the Round Hickorynut, that may occur downstream from these agricultural activities.

Stressor: Dams and Barriers
Exposure:
Response:
Consequence:
Narrative: The effects of impoundments and barriers on aquatic habitats and freshwater mussels are relatively well-documented (Watters 2000, p. 261). This section is intended to be a summary of the effects (as opposed to a comprehensive overview) that dams and other barriers have on

the Round Hickorynut. Extinction/extirpation of North American freshwater mussels can be traced to impoundment and inundation of riffle habitats in all major river basins of the central and eastern U.S. (Haag 2009, p. 107). Humans have constructed dams for a variety of reasons: flood control, water storage, electricity generation, irrigation, recreation, and navigation (Eissa and Zaki 2011, p. 253). Dams, either natural (by beavers or by aggregations of woody debris) or man-made, have many impacts on stream ecosystems. Reductions in the diversity and abundance of mussels are primarily attributed to habitat shifts caused by impoundments (Neves et al. 1997, p. 63). The survival of mussels and their overall reproductive success are influenced: ● Upstream of dams – the change from flowing to impounded waters, increased depths, increased buildup of sediments, decreased dissolved oxygen, and the drastic alteration in resident fish populations. ● Downstream of dams – fluctuations in flow regimes, minimal releases and scouring flows, seasonal depletion of dissolved oxygen, reduced or increased water temperatures, and changes in fish assemblages.

Stressor: Changing Climate Conditions
Exposure:
Response:
Consequence:
Narrative: Changing conditions that can influence freshwater mussels include increasing or decreasing water temperatures and precipitation patterns that increase flooding, prolong droughts, or reduce stream flows, as well as changes in salinity levels (Nobles and Zhang 2011, pp. 147–148). An increase in the number of days with heavy precipitation over the next 25 to 35 years is expected across the Round Hickorynut's range (US Global Climate Change Research Program 2017, p. 207). Although the effects of climate change have potentially affected the Round Hickorynut, the timing, frequency, and extent of these effects is currently unknown.

Stressor: Resource Extraction
Exposure:
Response:
Consequence:
Narrative: Across the Round Hickorynut's range, the most significant resource extraction impacts are from coal mining and oil and gas exploration. Activities associated with coal mining and oil and gas drilling can contribute chemical pollutants to streams. Acid mine drainage (AMD) is created from the oxidation of iron-sulfide minerals such as pyrite, forming sulfuric acid (Sams and Beer 2000, p. 3). This AMD may be associated high concentrations of aluminum, manganese, zinc, and other constituents (Tennessee Department of Environment and Conservation (TDEC) 2014, p. 72). These metals, and the high acidity saline drainage typically associated with AMD, can be acutely and chronically toxic to aquatic life (Jones 1962, p. 196). Implementation of the Surface Mining Control and Reclamation Act of 1977 has significantly reduced AMD from new coal mines; however, un-reclaimed areas mined prior to this regulation continue to generate AMD in portions of the Round Hickorynut's range.

Stressor: Forest Conversion
Exposure:
Response:
Consequence:
Narrative: A forested landscape provides many ideal conditions for aquatic ecosystems. Depending on the structure and function of the forest, and particularly if native, natural mixed

hardwood-conifer forests comprise the active river area, rain is allowed to slowly infiltrate and percolate (as opposed to rapid surface runoff). A variety of food resources enter the stream and river via leaf litter and woody debris; banks are stabilized by tree roots; habitat is created by occasional wind throw; and riparian trees shade the stream or river and maintain thermal climate. Silvicultural activities, when performed according to strict forest practices guidelines or BMPs, can retain adequate conditions for aquatic ecosystems; however, when forest practice guidelines or BMPs are not followed, these activities can also cause measurable impacts and contribute to myriad stressors facing aquatic systems throughout the eastern U.S. (Warrington et al. 2017, p. 8). Both small- and large-scale forestry activities have significant impacts depending on the physical, chemical, and biological characteristics of adjacent streams.

Stressor: Invasive and Nonnative Species
Exposure:
Response:
Consequence:
Narrative: Approximately 42 percent of federally endangered or threatened species are estimated to be significantly affected by nonnative, nuisance species across the nation, and nuisance species are significantly impeding recovery efforts for them in some way (National Invasive Species Council Management Plan 2016, p. 2). When a nonnative species is introduced into an ecosystem, it may have many advantages over native species, such as easy adaptation to varying environments and a high tolerance of living conditions that allow it to thrive in its new habitat. There may not be natural predators to keep the nonnative species in check; therefore, it can potentially be more successful and reproduce more often, further reducing the biodiversity in the system. The native species may become an easy food source for invasive species, or the invasive species may carry diseases that extirpate populations of native species. Examples of nonnative species that affect freshwater mussels like the Round Hickorynut are the Asian Clam (Corbicula fluminea), Zebra Mussel (Dreissena polymorpha), Quagga Mussel (Dreissena bugenis), Black Carp (Mylopharyngodon piceus), Round Goby (Neogobius melanostomus), Didymo (a.k.a. rock snot; Didymosphenia geminata), and Hydrilla (a.k.a. water-thyme; Hydrilla verticillata).

Recovery

Conservation Measures and Best Management Practices:

- Permits to fill wetlands and fill, culvert, bridge, or re-align streams or water features are issued by the Corps under Nationwide Permits, Regional General Permits, or Individual Permits. ● Nationwide Permits are for “minor” impacts to streams and wetlands, and do not require an intense review process. These include stream impacts under 150 ft (45.7 m), and wetland fill projects up to 0.50 ac (0.2 ha). Mitigation is usually provided for the same type of wetland or stream affected, and is usually at a 2:1 ratio to offset losses and make the “no net loss” closer to reality. ● Regional General Permits are for various specific types of impacts that are common to a particular region; these permits will vary based on location in a certain region/state. ● Individual Permits are for the larger, higher impact and more complex projects. These require a complex permit process with multi-agency input and involvement. Impacts in these types of permits are reviewed individually and the compensatory mitigation chosen may vary depending on project and types of impacts.(USFWS, 2019)

Additional Threshold Information:

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References

USFWS. 2019. Species Status Assessment Report for the Round Hickorynut Mussel (Obovaria subrotunda), Version 1.0. Asheville Ecological Services Field Office, Asheville, North Carolina.
USFWS. 2022. Species Status Assessment Report for the Round Hickorynut Mussel (Obovaria subrotunda). Version 1.1. U.S. Fish and Wildlife Service. Region 4. Atlanta, GA.

USFWS. 2023. Endangered and Threatened Wildlife and Plants

Threatened Species Status With Section 4(d) Rule for Longsolid and Round Hickorynut and Designation of Critical Habitat. FR Vol. 88, No. 46. Pages 14794-14869. Final Rule.

USFWS. 2019. Species Status Assessment Report for the Round Hickorynut Mussel (Obovaria subrotunda), Version 1.0. Asheville Ecological Services Field Office, Asheville, North Carolina.

USFWS. 2019 2019. Species Status Assessment Report for the Round Hickorynut Mussel (Obovaria subrotunda), Version 1.0. Asheville Ecological Services Field Office, Asheville, North Carolina.

SPECIES ACCOUNT: *Pegias fabula* (Littlewing pearlymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4) (USFWS, 2015)

Physical Description

Pegias fabula is a small freshwater mussel or bivalve mollusk which attains an average adult size of 24 mm. in length. The outer shell is usually eroded away in mature individuals. A few dark rays are apparent along the base of the shell in young individuals.

Taxonomy

The little-wing pearly mussel (Peciias fabula) was originally described from a male specimen by Lea (1838) as Marciaritana fabula. Simpson (1900) placed the species in a new genus Pepias and listed previous taxonomic synonyms. Ortmann (1913-1914) considered Pecjias to be a subgenus of Alasmidonta ; however, that opinion has not been followed by most subsequent authorities. The U.S. Fish and Wildlife Service follows Simpson (1900) and Clarke (1981) in considering Marciaritana curreviana Lea, 1840, to be a synonym of Pepias fabula. For a detailed synonymy, see Clarke (1981) and Bogan and Parmalee (1983). Lectotype specimens are located at the U.S. National Museum, Washington, D.C. Pictures are available in Burch (1973, 1975), Clarke (1981), Bogan and Parmalee (1983), and Ahlstedt (1986). (USFWS, 1989)

Historical Range

Historically, Pegias fabula was widespread but uncommon, known from 27 stream reaches in the Tennessee and Cumberland River systems in Alabama, North Carolina, Tennessee, Kentucky, and Virginia (USFWS, 1989). In Kentucky, the species was found in Rockcastle River, Laurel and Rockcastle Counties; Buck and Pitman Creeks, Pulaski County, and West Fork Red River, Todd County. Several sites are known from Virginia: South Fork Holston River, Washington County; Big Mocassin and Copper Creeks, Scott County. Historically in Tennessee, it has been collected from the Collins River in Warren Co. (Athearn 1992); the Duck River; the Elk River at Estell Spring in Franklin Co.; Cane Creek in 1967, a tributary to the Caney Fork River (Athearn, 1992); and Buck Creek and the Stones River; all part of the Cumberland River drainage (Parmalee and Bogan, 1998). In Tennessee it was known from the Collins River, Warren County; Stones River in Rutherford County. The species is likely extirpated from Alabama where it was historically found in Bluewater Creek, Lauderdale Co., and possibly other Tenenssee River tributaries (Mirarchi et al., 2004; USFWS, 1989). Surveys in 1986 found this species in six short stream reaches of the Tennessee and Cumberland River basins. (NatureServe, 2015)

Current Range

Species continues to be rare and only a few individuals have been observed over the past few years. Only one viable population (Big South Fork Cumberland River) is believed to exist; all other populations are believed to consist of only remnant individuals. Surveys conducted in 2010 in the Rockcastle River basin (KY) by the KDFWR produced 1 fresh dead individual from Horse Lick Creek, a tributary of the Rockcastle River. No littlewing pearlymussels were observed in the Rockcastle River main stem (total of 10 sites). Based on our analysis, the most significant threats identified in the recovery plan continue to impact the species and only one viable population of the species is believed to exist. The littlewing pearlymussel is currently restricted to six watersheds in Kentucky, Tennessee, North Carolina, and Virginia: BSFCR, Rockcastle River, Cane Creek, Clinch River, North Fork Holston River, and Little Tennessee River. Unfortunately, the Service believes that the status of the littlewing pearlymussel has worsened since the recovery plan was published in 1989. For example, recent survey efforts indicate a drastic decline of this species in Horselick Creek, a stream considered as one of the healthiest known populations in 1989. Except for the BSFCR population, all known populations have diminished since the recovery plan was written and now likely consist of only remnant individuals. These populations are not considered to be viable according to the definition of viability presented in the recovery plan. The best remaining population of littlewing pearlymussel occurs within the BSFCR in portions of Kentucky and Tennessee. This population has shown evidence of recruitment in recent years and is currently considered the only known viable population. However, the BSFCR population remains vulnerable to impacts from coal mining and oil extraction activities, and additional survey efforts are needed to better define the extent of this species in the river and identify locations that may be appropriate for population enhancement activities.

Critical Habitat Designated

No;

Life History

Reproduction Narrative

Adult: Limited life history work has been accomplished on this species, but at least three fish species have been determined to serve as suitable glochidial hosts. They include the black sculpin, Cottus baileyi, greenside darter, Etheostoma blennioides, and emerald darter, E. baileyi. Some success at rearing juveniles to a few weeks of age before release into the wild has occurred. This species is apparently difficult to maintain alive for extended periods of time in captivity (Dr. Monte McGregor, personal communication, KDFWR, 2007). Ahlstedt (1986) suggests the species is a winter brooder (long-term). Six gravid females collected for propagation of juveniles in 2004 produced a total of 209 juveniles; however, all juveniles died by 4 weeks of age (Petty, 2007). Survival of these juveniles likely was poor due to the use of immature glochidia. Propagation efforts are ongoing at the KDFWR's Center for Mollusk Conservation in Frankfort, Kentucky using gravid females from a recent collection.

Habitat Narrative

Adult: This freshwater, benthic species is most common at the head of riffles, but also found in and below riffles on sand and gravel substrates with scattered cobbles. It also inhabits sand pockets between rocks, cobbles and boulders, and underneath large rocks (Gordon and Layzer, 1989). It is restricted to small, cool streams. It is usually found lying on top or partially buried in sand and fine gravel between cobble in only 6 to 10 inches of water. It is usually found at the head of riffles (Bogan and Parmalee, 1983; Stansbery, 1976).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Trends:

Declining (USFWS, 2020)

Number of Populations:

1 (USFWS, 2020)

Adaptability:

All populations are small and isolated, restricting genetic interchange and impeding natural dispersal capability (USFWS, 1989). (NatureServe, 2015)

Population Narrative:

Declining. Little-wing Pearlymussel1 continues to be rare and only a few individuals have been observed over the past few years. It historically occurred in the Tennessee and Cumberland River drainages in northern Alabama, southern Kentucky, western North Carolina, Tennessee, and southwestern Virginia. Currently, a relatively short reach of the Big South Fork Cumberland River (BSFCR) in Tennessee and Kentucky contains the only population that may be viable. The species is extant in Cane Creek, Tennessee, but survey effort has been limited and not sufficient to provide more information about the status of that population (USFWS, 2020)

Threats and Stressors

Stressor: Industrial and municipal pollution
Exposure:
Response:
Consequence:
Narrative:

Stressor: Oil extraction, coal mining, acid mine drainage
Exposure:
Response:
Consequence:
Narrative:

Stressor: Siltation resulting from mining, agriculture, and construction activities
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:

The littlewing pearlymussel will be considered for downlisting or reclassification from endangered to threatened status upon completion of the following (USFWS 1989): Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional populations, a total of eight distinct viable populations (see following note) exist in the Cumberland and Tennessee River systems.

Biological and ecological studies have been completed, and the recovery measures developed and implemented from these studies are beginning to be successful as evidenced by recruitment and an increase in population density and/or an increase in the population size and length of river reach inhabited within each of the eight populations.

Delisting Criteria:
The littlewing pearlymussel will be considered for delisting upon completion of the following (USFWS 1989): Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional populations, a total of 13distinct viable populations (see following note) exist in the Cumberland and Tennessee River systems.

Studies of the mussel's biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful, as evidenced by recruitment and an increase in population density and/or increase in the population size and length of river reach inhabited within each of the 13 populations.

No foreseeable threats exist that would likely threaten survival of any of these 13 populations.

Where habitat had been degraded, noticeable improvements in water and substratum quality have occurred.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The following actions are generally ordered based on priority, with the higher priority actions listed towards the top. • Conduct research to understand genetic diversity between and within extant populations to inform reintroductions and long-term management. • Continue to develop propagation techniques to support population reintroductions and augmentations. • Continue efforts to monitor the population in BSFCR and introduce propagated juveniles to expand the population into formerly occupied reaches (i.e., from the known occupied reach downstream to the backwaters of Lake Cumberland). • Take appropriate actions to eliminate or reduce threats to this species in the BSFCR and Cane Creek. Regulations that apply to coal mining and oil extraction activities should to be strictly enforced to prevent the loss of these populations. • Conduct additional surveys for the species in the Caney Fork basin to establish the current distribution. Identify opportunities for population reintroduction/ augmentation. • Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality. For example, the following streams were recommended by the Cumberlandian Region Mollusk Restoration Committee (2010): Tennessee River system – Tennessee tributary tailwaters: Elk River, AL and TN; lower French Broad/Holston Rivers, TN, upper Clinch River, TN; Nolichucky River, TN; Duck River, TN; Emory River, TN; Obed River, TN; South Fork Holston River, VA; upper French Broad River, TN; lower Pigeon River, TN; Hiwassee River, TN; Copper Creek., VA; Fountain Creek, TN. Cumberland River system – Rockcastle River, KY; Middle Fork Rockcastle River, KY; Sinking Creek, KY; Buck Creek., KY; Roundstone Creek; Clear Fork, TN; Collins River, TN; Big Hickory Creek, TN; Little South Fork, KY; Kennedy Creek, KY; East Fork Stones River, TN; Harpeth River, TN; Red River, KY/TN; Whippoorwill Creek., KY. • Continue to educate the public about water quality, biodiversity protection, and the value of freshwater mussels. (USFWS, 2020)

References

USFWS 2016. Status of the Species and Critical Habitat: Pegias fabula (Littlewing pearlymussel). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

U.S. Fish and Wildlife Service. 1989. Little-wing Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 29pp.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/ecp0/. Accessed April 4, 2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A." USFWS. 2020. Little-wing Pearlymussel (Pegias fabula, Lea, 1838). 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service North Atlantic-Appalachian Region Kentucky Ecological Services Field Office Frankfort, Kentucky. 28 pp.

NatureServe. 2015.

USFWS. 2020. Little-wing Pearlymussel (Pegias fabula, Lea, 1838). 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service North Atlantic-Appalachian Region Kentucky Ecological Services Field Office Frankfort, Kentucky. 28 pp.

SPECIES ACCOUNT: *Plethobasus cicatricosus* (White wartyback (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 06/14/1976, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

An oblong or elongate freshwater mussel, light brown, with a row of large tear-shaped tubercles running down the side of the shell. The shell is oblong, elongate, thick, and moderately inflated. Anterior end rounded, posterior end broadly rounded. Dorsal and ventral margins curved. Umbos low, directed forward and not elevated above the hinge line. Shell smooth, except for a single row of large pustules or knobs on the center of the valve, running from below the umbo to the edge. Periostracum yellow or light brown in juveniles, becoming chestnut to dark brown in adults. Faint green rays present on the umbo. Length to five inches. Pseudocardinal teeth large and well developed; two in the right valve, one in the right, with a smaller tooth on either side. Lateral teeth rather short, straight or slightly curved; two in the left valve, one in the right Beak cavity relatively shallow. Nacre white, iridescent posteriorly (Cummings and Mayer, 1992) (NatureServe, 2015).

Taxonomy

Thomas Say originally described Unio cicatricosus in 1829. Isaac Lea described Unio varicosus later the same year. Both names were widely used in the literature; however, varicosus Lea was pre-occupied by varicosus Lamarck, 1819. Frierson (1911) synonomized Unio cicatricosus Say with Unio aesopus Green, 1827 (= Plethobasus cyphyus Rafinesque, 1820) and renamed Lea's shell as Unio detectus Frierson, 1911. He also named two additional species Unio cicatricoides and Unio comptertus as being part of this complex. In 1919, Ortmann synonomized all of Frierson's names under cicatricosus Say. Three years later Ortmann and Walker (1922) sunk cicatricosus into cyphyus. Recent authors have not followed Ortmann and Walker (1922) and recognize Plethobasus cicatricosus as distinct (Parmalee, 1967; Bogan and Parmalee, 1983; Cummings and Mayer, 1992; Turgeon et al., 1998) (NatureServe, 2015).

Historical Range

Historically, this species was widely distributed in the Ohio, Cumberland, and Tennessee drainages including the Wabash, Ohio, Kanawha, Cumberland, Holston, and Tennessee rivers (USFWS, 1984). No live specimens have been found in the Wabash, Ohio, Kanawha, Cumberland, or Holston rivers since around the turn of the century. It historically occurred in the Wabash mainstem in Indiana (Fisher, 2006) (NatureServe, 2015).

Current Range

It possibly still exists in a very short reach of the Tennessee River mainstem below Pickwick Dam near Savannah, Tennessee, near river mile 207 because all of the most recent historical records were from the original Tennessee River channel (USFWS, 1984; Parmalee and Bogan, 1998). The only other potential extant population is in the tailwaters of Wilson Dam on the Tennessee River where it is rare (Mirarchi et al., 2004) (NatureServe, 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: No information available.

Reproduction Narrative

Adult: The glochidial host is not known (NatureServe, 2015). The breeding season is unknown, but this species may be tachytictic based on Wilson and Clark's (1914) observations for a closely related species, P. cooperianus (USFWS, 1984).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species was presumed to inhabit shoals and riffles in large rivers like the Tennessee (Bogan and Parmalee, 1983). The environmental specificity of this species is very narrow, as is restricted to riffles in large rivers; most of which are now impounded. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). Freshwater mussels are benthic animals (USFWS, 1984).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

> 90% decline (NatureServe, 2015)

Species Trends:

> 70% decline (NatureServe, 2015)

Number of Populations:

1 (NatureServe, 2015)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Adaptability:

Very low (inferred from NatureServe, 2015)

Population Narrative:

If any populations still remain, they are isolated and extremely small with poor viability in the Tennessee River with poor dispersal capability (USFWS, 1989). No live specimens have been found in the Holston River, Cumberland River, Ohio River, Wabash River, and Konawha River since before the turn of the 20th Century (USFWS, 1989). This species has experienced a long-term decline of >90% and a short-term decline of > 70%. The range extent is less than 40 square miles, with one possibly extant population (NatureServe, 2015). The only known extant populations of white wartyback are known from a reach of the Tennessee River downstream of Wilson Dam, in Alabama and near Savannah Tennessee. Surveys over the last few decades have only detected a few individuals of this species and evidence of reproduction is scant (USFWS, 2023).

Threats and Stressors

Stressor: Habitat modification and degradation (NatureServe 2015)

Exposure:
Response:
Consequence:
Narrative: Destruction of habitat through stream channelization and maintenance and the construction of dams is still a threat in some areas. Impoundments reduce currents that are necessary for basic physiological activities such as feeding, waste removal and reproduction. In addition, reduced water flow typically results in a reduction in water oxygen levels and a settling out of suspended solids (silt, etc.), both of which are detrimental. Dredging of streams has an immediate effect on existing populations by physically removing and destroying individuals. Dredging also affects the long-term recolonization abilities by destroying much of the potential habitat, making the substrates and flow rates uniform throughout the system (NatureServe, 2015).

Stressor: Zebra mussels (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Zebra mussels, Dreissena polymorpha, have destroyed mussel populations in the Great Lakes and significantly reduced mussels in many of the large rivers of eastern North America. Zebra mussels have the potential to severely threaten other populations especially if they make their way into smaller streams (NatureServe, 2015).

Stressor: Pollution (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Pollution through point (industrial and residential discharge) and non-point (siltation, herbicide and fertilizer run-off) sources is perhaps the greatest on-going threat to this species and most freshwater mussels. Lowered dissolved oxygen content and elevated ammonia levels (frequently associated with agricultural runoff and sewage discharge) have been shown to be lethal to some species of freshwater naiads (Horne and McIntosh, 1979). Residential, mineral and industrial development also pose a significant threat. Rotenone, a toxin used to kill fish in bodies of water for increased sport fishery quality, has been shown to be lethal to mussels as well (Heard, 1970) (NatureServe, 2015).

Recovery

Reclassification Criteria:
No downlisting criteria are given in the recovery plan (USFWS, 2007)

Recovery Priority Number: 5

Delisting Criteria:
Criterion 1. A viable population of Plethobasus cicatricosus exists in the Tennessee River. This population is dispersed to an extent that it is unlikely that any one event would cause the loss of the entire population (USFWS, 2023).

Criterion 2. Through reestablishment and/or by discoveries of new populations, viable populations exist in two additional rivers. Each river will contain a viable population that is distributed such that a single event would be unlikely to eliminate Plethobasus cicatricosus from the river system. For reestablished populations, surveys must show that three year-classes including one year class 10 years old or older have been naturally produced within the river system (USFWS, 2023).

Criterion 3. The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (USFWS, 2023).

Recovery Actions:

- Preserve any known populations and presently used habitat (USFWS, 1984)
- Determine the feasibility of introducing the species back into rivers within its historic range and introduce where feasible (USFWS, 1984).
- Conduct life history studies (USFWS, 1984).
- Determine the number of individuals required to maintain a viable population (USFWS, 1984).
- Investigate the necessity for habitat improvement and, if feasible and desirable, identify techniques and sites for improvement to include implementation (USFWS, 1984).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations (USFWS, 1984).
- Assess overall success of recovery program and recommend action (USFWS, 1984).
- Recommendations for future actions: A. The Service should continue working with TVA to ensure hydropower and flood control operations at Wilson Dam and associated monitoring are implemented in compliance with the BO. B. Increase the probability of successful reproduction and propagation by collecting adults and placing them in aggregations below Wilson Dam to increase the odds it will increase their reproductive success. C. Initiate efforts aimed at identifying potential fish hosts, obtaining individuals, and improving techniques necessary for captive propagation of the species. D. Once captive propagation techniques have been tested using surrogate species, pursue captive breeding. E. Initiate a study of dietary needs and metabolism. F. Improve utilization of existing legislation and regulations. G. Continue efforts to reduce non-point pollution from agriculture. H. Investigate role of point source pollution impacts on freshwater mussel species (USFWS, 2016).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (Service 1984). Recovery Activities 1. The Service should continue working with TVA to ensure hydropower and flood control operations at Wilson Dam and associated monitoring are implemented. 2. Increase the probability of successful reproduction and propagation by collecting adults and placing them in aggregations below Wilson Dam to increase the odds it will increase their reproductive success during spawning. Consider use of in vitro propagation. 3. If viable population numbers are discovered, the Lower French Broad and Lower Holston Rivers have been designated an experimental population location (FR 71, Number 113, Jun 13 2006). Monitoring and Research Activities 1. Conduct additional mussel surveys to confirm the presence of the white wartyback in locations where it is known; or believed to be found. Surveys should be conducted in the Tennessee River below Wilson Dam and near Savannah Tennessee both above and below Pickwith Dam. Confirm species identification using DNA analysis. 2. Initiate efforts aimed at identifying potential fish hosts, obtaining individuals, and improving techniques necessary for captive propagation of the species. 3. Once captive propagation techniques have been tested using a surrogate species, pursue captive propagation efforts when individuals of this species are found. 4. Initiate a study of the dietary needs and metabolism of large river obligate species to better understand the niche and needs of white wartyback in the system. 5. Research trans location techniques and risks for this species. 6. Improve utilization of existing legislation and regulations (federal and state endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat. 7. Continue efforts to reduce non-point pollution from agricultural activities by working through the U.S. Fish and Wildlife Partners for Fish and Wildlife, U.S. Department of Agriculture Farm Bill, and other landowner incentive programs to implement BMPs. 8. Investigate role of point source pollution impacts to freshwater mussel species in the Wilson Dam tailwater, specifically those emanating from the wastewater treatment plant located at Seven-mile Island. 9. Implement eDNA survey methods to determine presence of species in waterways (USFWS, 2023).

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 1984. White Warty-back Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 43 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2023. White Wartyback (Plethobasus cicatricosus) Status Review: Summary and Evaluation. South Atlantic-Gulf Region. Alabama Ecological Services Field Office. Daphne, Alabama. 11 pages.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS 2007. Endangered and Threatened Wildlife and Plants

Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee

Final Rule. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461.

Final Rule. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461

USFWS. 2016. White wartyback (Plethobasus cicatricosus). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Southeast Region. Tennessee Ecological Services Field Office. Cookeville, Tennessee.

USFWS. 2023. White Wartyback (Plethobasus cicatricosus) Status Review: Summary and Evaluation. South Atlantic-Gulf Region. Alabama Ecological Services Field Office. Daphne, Alabama. 11 pages.

SPECIES ACCOUNT: *Plethobasus cooperianus* (Orangefoot pimpleback (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 06/14/1976, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

The orangefoot pimpleback (Plethobasus cooperianus) is an Ohioan species (i.e., Interior Basin) species. Records are only known from the Ohio River basin. It was officially listed as an endangered species on July 14, 1976 (Code of Federal Regulations 1976). The orangefoot pimpleback is a medium-sized mussel, growing to a length of approximately 3.5 inches. The shell is circular or sub-triangular in shape, with prominent beaks that are directed anteriorly. The periostracum is brown to reddish-brown and the surface of the shell is marked by concentric growth lines. The posterior two-thirds of the shell are covered with numerous raised, irregular pustules (Parmalee and Bogan 1998). Nacre color varies from white to pink inside the pallial line, being more intense toward the hinge-teeth (Bogan and Parmalee 1983).

Taxonomy

This species was originally described with the specific epithet cooperianus by Lea in 1834. Bogan and Parmalee (1983) considered Obovaria striata Rafinesque, 1820, to be the same species and gave priority to Rafinesque's name. Most authors and Turgeon et al. (1998) use the epithet cooperianus. (NatureServe, 2015)

Historical Range

The historical range included the Ohio River from western Pennsylvania to southern Indiana, the Wabash River below Mt. Carmel, Illinois, the Cumberland River from Cumberland County, Kentucky to the vicinity of Nashville, Tennessee, the lower Clinch River in Anderson County, Tennessee, and the Tennessee River from near Knoxville to Kentucky Lake, Benton County, Tennessee. It has also been reported from the Caney Fork, Holston, and French Broad rivers in Tennessee and the Green and Rough rivers in Kentucky (USFWS, 1984; Parmalee and Bogan, 1998). Historical occurrences that are believed to be no longer extant (some subfossil) include the Kanawha River, West Virginia; Wabash River, Indiana; Rough River, Kentucky; Duck River, Tennessee; and questionably the "Ohio River", Pennsylvania (USFWS, 1984). Reports from the Mississippi River by Simpson (1914) and others are incorrect (see Bogan and Parmalee, 1983). (NatureServe, 2015)

Current Range

Historical records for the orangefoot pimpleback indicate this species is strictly an Ohioan or Interior Basin species (i.e., Ohio, Cumberland and Tennessee river drainages) (Ortmann, 1919). Populations of the orangefoot pimpleback continue to occur in the lower Ohio River and in the Tennessee River, while the best remaining population of the species occurs in the lower, free-flowing reach of the Ohio River, and in the riverine portion of Kentucky Lake downstream of Pickwick Landing Dam in Tennessee. Hubbs (2010b) recently collected two individuals from the Pickwick Landing Dam tailwater that were approximately seven years in age, demonstrating recruitment in this Tennessee River population of the orangefoot pimpleback. It is not known if any genetic interchange is occurring between the two populations in the Ohio and Tennessee Rivers. The Cumberland River does not currently contain a known viable population of the species, but individuals may still exist there in low numbers (Widlak 2010). No new populations of orangefoot pimpleback have been discovered and populations have not yet been reestablished in historic habitat. The lower French Broad River and lower Holston River have, however, been recently designated for establishment of nonessential experimental populations of the species. When the orangefoot pimpleback is collected during surveys, older, often eroded, adult specimens of this species are sampled (Widlak 2010). Rangewide trend – The orangefoot pimpleback was historically known from the Ohio River (from western Pennsylvania to southern Indiana), the Wabash River (below Mt. Carmel, Illinois), the Cumberland River (from Cumberland County, Kentucky to near Nashville, Tennessee), the lower Clinch River (Anderson County, Tennessee) and the Tennessee River (near Knoxville to Benton County, Tennessee) and has also been reported from the Caney Fork, Holston, and French Broad Rivers in Tennessee, and the Green and Rough Rivers in Kentucky (NatureServe 2003). The largest known populations remain in the lower, free-flowing reach of the Ohio River downriver from the confluence of the Tennessee River at Paducah, and a short reach of the Tennessee River below Pickwick Landing Dam (USFWS 1984, Miller et al. 1986). The Cumberland River may continue to support individuals of the species, but none have been collected from that system in recent decades. The Service (Code of Federal Regulations 2007) is currently planning future releases of the orangefoot pimpleback into the lower French Broad and lower Holston Rivers Experimental Population Area, under a Nonessential Experimental Population designation to further the recovery and conservation of the species. Live orangefoot pimplebacks have recently been recovered from commercial mussel harvesters in the vicinity of the lower Ohio River near Lock and Dam 52. Several of these individuals are currently being held by the KDFWR to be used for propagation and reintroduction purposes in the near future. Surveys of mussel beds in the lower Ohio River from July through October 2007 yielded 24 orangefoot pimplebacks (Widlak 2010). The TWRA collected a seven year old individual at TRM 170 in the vicinity of Swallow Bluff Island in 2009 and have collected several seven and eight year old orangefoot pimpleback mussels in the Pickwick Landing Dam tailwater in recent years, indicating that some level of recruitment is occurring in this reach of the Tennessee River. The orangefoot pimpleback also continues to be found in the lower Tennessee River downstream of Kentucky Dam, but no recruitment of the species has been recently noted in Kentucky waters (Lewis 2008). This individual, 3.1 inches in length, was discovered on June 18, 2008 during a pre-project survey of the proposed project area.

Critical Habitat Designated

Yes;

Life History

Reproduction Narrative

Adult: The reproductive cycle of the orangefoot pimpleback is likely similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The orangefoot pimpleback is likely a short term brooder with spawning occurring in the spring and release of glochidia during summer months (USFWS 1984). Wilson and Clark (1914) collected two gravid females in early June. Utterback (1915) reported the orangefoot pimpleback to be a summer breeder and Yokley (1972a) observed one specimen with gills charged in August. The glochidia of the orangefoot pimpleback have not been described, but the sexual glands and soft parts are usually pinkish in color and also grayish or brown (USFWS 1984). The glochidia have been observed to be pale orange in June (Hubbs 2010b). It is probable that the glochidia are semi-oval, and hookless, similar to those in the closely related species, sheepnose (Plethobasus cyphyus) (Ortmann 1912, 1919). Specific glochidial hosts for this species are unknown; however, the sauger (Stizostedion canadense) is reported by Surber (1913) and Wilson (1916) to be the fish host for the orangefoot pimpleback. The Kentucky Department of Fish and Wildlife Resources, under the direction of Dr. Monte McGregor is planning studies to identify the species' fish host(s) and other life history aspects, and is maintaining captive individuals at their Center for Mollusk Conservation in Frankfort, Kentucky.

Habitat Narrative

Adult: The orangefoot pimpleback is found in medium to large rivers with sand and gravel substrates (USFWS 1984). This species is endemic to the Ohio River system where it is found in fl.owing water habitats (i.e., large rivers such as the Ohio and Tennessee Rivers that are relatively deep and wide rivers) with stable substrates comprised of a mixture of relatively firm and clean gravel, sand, and silt. Orangefoot pimpleback mussels are often associated with other riverine mussel species (e.g., Plethobasis cyphyus, Cyclonaias tuberculata, Fusconaia ebena, etc.) that also prefer this type of habitat (USFWS, 2018).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Number of Populations:

3 (USFWS, 2023)

Population Narrative:

Population variability – This species is considered extremely rare wherever it is found. Little is known on the population variability of the orangefoot pimpleback. Few individuals are observed during survey efforts, making it difficult to accurately assess populations. In the Tennessee River, the Pickwick Landing Dam tailwater supports the only known population in which recent recruitment has been observed. The Tennessee Wildlife Resources Agency collected a seven year old individual at TRM 170 in the vicinity of Swallow Bluff Island in 2009. Finding mussels of this early age indicates that some level of recruitment is occurring in this reach of the Tennessee River (Don Hubbs 2010a). During a June 17-21, 2008 pre-project survey at TRM 160.7, one orangefoot pimpleback was collected and comprised <0.001 percent of the total species composition (11,090 native mussels, representing 17 species) (Shaw 2010). Population stability – The stability of orangefoot pimpleback populations is not well known. In most locations where this species appears to be present, the presence of orangefoot pimplebacks is evident from occasional individuals or only a few individuals recorded. In the Ohio River, the low numbers typically encountered during mussel surveys, is of little value other than indicating the species may be existing in a certain area over a relatively long period of time. The orangefoot pimpleback is a mussel native to large rivers in sand and gravel substrates. The Service is aware of three remaining populations or potentially occupied reaches: the Tennessee River, Ohio River, and Cumberland River. These populations are unlikely to experience genetic exchange or survive a catastrophic event. The species is extremely rare compared to other native mussels, even where it is found (USFWS, 2023).

Threats and Stressors

Stressor: impoundments, siltation, and pollution
Exposure:
Response:
Consequence:
Narrative: The recovery plan for the orangefoot pimpleback provides reasons for listing this species including: impoundments, siltation, and pollution. Impoundments alter flow, temperature regimes, and water quality and habitat conditions creating conditions unsuitable for riverine mussels and/or their host fish. Siltation can increase turbidity which irritates or clogs the gills of mussels and can even physically smother the animal. Mussel life cycles can be affected indirectly from siltation by impacting host fish populations (e.g., smothering fish eggs or larvae, reducing food availability, etc.). Various forms of pollution from municipal, agricultural, and industrial sources can impact mussels in a variety of ways. The orangefoot pimpleback is an extremely rare mussel. Generally, only one or two individuals are collected, if any, in suitable habitat supporting an abundance of other mussel species. Historically, it had a relatively restricted distribution in that the species was only reported from the Ohio, Tennessee and Cumberland rivers and their larger tributary streams (USFWS 1984). Alteration and destruction of habitat, due to creation of impoundments for flood control, navigation, hydroelectric power production and recreation, and activities resulting in siltation which affected substrate quality (e.g., navigation traffic, sand and gravel mining), led to the listing of the orangefoot pimpleback; these impacts continue to affect the species' habitat (USFWS 1984; James Widlak 2010). The orangefoot pimpleback is not a species that is collected for commercial purposes; however, commercial mussel harvest may have contributed to some decline in populations due to the species being unintentionally collected along with commercially valuable species. However, these impacts are believed to be minor in regards to declining population levels (Widlak 2010).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure:
Response:
Consequence:
Narrative: Regulated point sources may adversely affect the orangefoot pimpleback mussel. Freshwater mussels appear to exhibit more sensitivity to some pollutants than organisms typically used in toxicity testing. As a result, some of the water quality criteria established by the U.S. Environmental Protection Agency to protect aquatic life may not be protective of mussels. For example, Augspurger et al. (2003) found that the current EPA numeric criteria for ammonia may not protect mussels. Consequently, sewage treatment plants that comply with their ammonia effluent limits may still be discharging water that is toxic to mussels. Few substances have been tested for their toxicity to mussels and none on orangefoot pimpleback mussels. "Safe" concentrations of regulated pollutants for this species are not yet known. Agriculture, suburban, and urban land uses continue to expand in many watersheds within the current range

of the species. Land use changes alter runoff patterns and flow in this species' habitat, and the consequences of such changes to these remaining populations are not known. Few regulatory mechanisms exist to address land use changes that may indirectly affect stream habitats far from the source of disturbance (USFWS, 2018).

Stressor: Other natural or manmade factors affecting its continued existence
Exposure:
Response:
Consequence:
Narrative: Zebra mussels have continued to spread in North American waterways since their accidental introduction in the 1980s. Zebra mussel densities in the Tennessee River system downstream of Wilson and Pickwick Landing dams increased significantly during 2016-2017, and the species currently persists in numbers as high as 12,000 per square meter, posing an increased threat to orangefoot pimpleback persistence in this reach (Hubbs 2017d). Zebra mussels could also influence recovery actions to benefit this species by limiting the number of suitable locations where new populations could be established and/or impacting newly established populations. Low recruitment of the orangefoot pimpleback is likely contributing to declining populations. Since the orangefoot pimpleback is a relatively long-lived species, the rate of decline may not be evident given the uncertainty of finding this species in the wild. Reasons for a low recruitment are not known; however, it may involve single or multiple factors, such as difficulty of females being fertilized by sperm, lack of fish host(s), degraded water quality, and other factors. Small isolated populations also represent a threat to the species from lack of gene flow resulting in decreased diversity, and greater susceptibility to extirpation from stochastic or catastrophic events (USFWS, 2018).

Recovery

Reclassification Criteria:
Recovery Priority Number: 5

Delisting Criteria:
a. A viable population of P. cooperianus exists in the Tennessee, Cumberland, and Ohio Rivers. These three populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population. b. Through reestablishment and/or by discoveries of new populations, viable populations exist in two additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate P. cooperianus from the river system. For reestablished populations, surveys must show that three year-classes including one year-class 10 years old or older have been naturally produced within the river system. c. The species and its habitat are protected from present and foreseeable human related and natural threats that may interfere with the survival of any of the populations. d. Noticeable improvements in siltation problems and substrate quality have occurred (USFWS, 2018).

Recovery Actions:
- The recovery plan outlined the following: (1) preserve populations and presently used habitats with emphasis on the Tennessee, Cumberland, and Ohio Rivers, (2) determine feasibility of introducing the species back into rivers within its historic range and introduce where feasible, (3) conduct life history studies (i.e. fish hosts, age and growth, reproductive

biology, longevity, natural mortality factors, and population dynamics), (4) determine the number of individuals required to maintain a viable population, (5) investigate the necessity for habitat improvement, and if feasible and desirable, identify techniques and sites for improvement to include implementation, (6) develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations, (7) assess overall success of recovery program and recommend action. The USFWS, in cooperation with the State of Tennessee and Conservation Fisheries, Inc., proposes to reintroduce this species into its historical habitat in the free-flowing reach of the French Broad River below Douglas Dam to its confluence with the Holston River, Knox County Tennessee, and in the free-flowing reach of the Holston River below Cherokee Dam to its confluence with the French Broad River (USFWS, 2006). Biological research needs – In order to effectively manage mussel species it is necessary to work out certain life history characteristics first. Because of their unusual life-cycle and dependence on fish for completion of that cycle, it is imperative that the host species for the orangefoot pimpleback be ascertained. Life history studies need to be done to identify age and size at sexual maturity, recruitment success, age class structure, and other important life history parameters. Research is needed to assess the success of watershed protection on mussel populations. Abundance and distribution of selected species needs to be monitored in order to ascertain how species abundance's change over time. From that we can assess what land-use changes, conservation practices, and physical/chemical parameters are correlated with, and possibly responsible for, the biological changes.

- RECOMMENDATIONS FOR FUTURE ACTIONS: Recommendation: Revise the recovery plan. The orangefoot pimpleback mussel recovery plan is nearly 33 years old and in need of revision. A revised plan will assist Federal, State and local entities in planning watershed and ecosystem actions to protect and improve habitat needed for future recovery efforts. A species status assessment should be completed prior to revision of the recovery plan. Recommendations for specific recovery actions: The following recovery actions should be made a priority over the next five years: 1) Additional surveys of known populations should be conducted to monitor their status and viability. 2) The fish host for the species should be identified and propagation and culture of juveniles to a suitable stocking size should be conducted once the fish host is known. This would facilitate the propagation and culture of the species and help inform site selection for restoring populations in other rivers based on the presence of the host fish in those rivers. 3) Captive husbandry methods should be developed, along with continued congregating in the wild, to increase the likelihood of spawning success and to make gravid individuals available for recovery efforts. Captive holding of orangefoot pimpleback mussels may provide additional options for the species' recovery and re-establishment into historical habitat. 4) In-vitro propagation and culture techniques should continue to be developed and utilized to produce juveniles that are of a suitable size for establishing new populations and augmenting existing populations. 5) The sensitivity of each life stage to selected contaminants that are likely to be found in streams should be determined and used to evaluate contaminant levels at potential augmentation and reintroduction sites. This should include assessment of interstitial water quality at augmentation and reintroduction sites. 6) An assessment of habitat should be completed to identify potential sites for orangefoot pimpleback mussel augmentation and reintroduction. 7) Threats and stressors should be identified and mapped within each river ecosystem where orangefoot pimpleback populations occur and at potential augmentation and reintroduction sites prior to any recovery efforts. 8) Age and growth analyses should be conducted to determine mean age-at-length and longevity of the species. This would help state and federal agencies and other stakeholders to understand the recruitment rates needed to sustain viable populations. 9) Recovery information should be obtained that includes (a) any evidence of recruitment in known populations, (b) maps depicting occupied habitat for each population, (c) maps of suitable and unsuitable habitat, (d) obstacles to population expansion in currently occupied habitat, (e) opportunities to expand population range within occupied rivers through active management, such as through propagation and translocation, and (f) identification of streams that have the ecological conditions needed to establish new populations (USFWS, 2018).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (Service 1984). In the course of this status review, potential recovery activities were identified and are included below. Recovery Activities Because of the limited number of orangefoot pimpleback individuals, current recovery activities should continue to focus on methodologies and planning for potential reintroductions. Between 2013-2022, a total of 55 orangefoot pimpleback individuals have been placed within a grid formation in the Tennessee River and are to be used as a source stock for propagation efforts. Given the low abundance of the species throughout its range, the close proximity of males and females within the grid allow for natural fertilization. In 2016, Dr. Monte McGregor, a malacologist with the Kentucky Department of Fish and Wildlife Resources (KDFWR), successfully used in-vitro metamorphosis to transform 5,000 larvae into juveniles. However, subsequent culturing and rearing were not successful. In 2022, a check for gravid orangefoot pimplebacks in the grid was conducted resulting in the retrieval of 32 individuals. Upon investigation by KDFWR personnel, six female orangefoot pimplebacks were found to be gravid and subsequently transported to a holding station located on Lake Cumberland, Kentucky. Dr. McGregor and other KDFWR personnel will use these individuals for propagation activities in upcoming years. Monitoring / Research Activities ● Conduct research on how zebra mussels are possibly outcompeting the orangefoot pimpleback populations for food and other resources. ● Conduct research on how orangefoot pimpleback responds to warming water temperatures caused by climate change. ● Conduct annual surveys to determine if conservation efforts are working. ● Collaborate with partners to fill research gaps related to the species biology and life history to support understanding of species resiliency, representation, and redundancy, including: ○ Age and growth analyses to estimate the longevity of the species. ○ Identification of the fish host for the species ○ Development of methods for propagation and culture of juveniles. ○ Identification of additional threats and stressors within each river ecosystem where orangefoot pimpleback population occurs. ○ Improve understanding of the potential effects of climate change on the species (USFWS, 2023).

References

USFWS 2016. Status of the Species and Critical Habitat: Plethobasus cooperianus (Orangefoot pimpleback). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2018. Orangefoot Pimpleback Plethobasus cooperianus 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service - Southeast Region Kentucky Field Office J.C. Watts Federal Building 330 West Broadway, Room 265 Frankfort, Kentucky 40601

USFWS 2016. Status of the Species and Critical Habitat: Plethobasus cooperianus (Orangefoot pimpleback). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016. USFWS. 2018. Orangefoot Pimpleback Plethobasus cooperianus 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service - Southeast Region Kentucky Field Office J.C. Watts Federal Building 330 West Broadway, Room 265 Frankfort, Kentucky 40601 USFWS. 2023. Orangefoot Pimpleback (Pearlymussel) (Plethobasus cooperianus) Status Review: Summary and Evaluation. Southeast Region. Kentucky Ecological Services Field Office. Frankfort, Kentucky. 11 pages.

USFWS. 2018. Orangefoot Pimpleback Plethobasus cooperianus 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service - Southeast Region Kentucky Field Office J.C. Watts Federal Building 330 West Broadway, Room 265 Frankfort, Kentucky 40601

USFWS. 2018. Orangefoot Pimpleback Plethobasus cooperianus 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service - Southeast Region Kentucky Field Office J.C. Watts Federal Building 330 West Broadway, Room 265 Frankfort, Kentucky 40601.

USFWS. 2023. Orangefoot Pimpleback (Pearlymussel) (Plethobasus cooperianus) Status Review: Summary and Evaluation. Southeast Region. Kentucky Ecological Services Field Office. Frankfort, Kentucky. 11 pages.

SPECIES ACCOUNT: *Plethobasus cyphyus* (Sheepnose Mussel)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

It is a medium-sized mussel that reaches nearly 5 inches in length. The shell is elongate ovate in shape, moderately inflated, and with thick, solid valves. There is a row of large, broad tubercular swellings on the center of the shell extending from the beak to the ventral margin. The dorsal margin of the shell is nearly straight, while the ventral margin is uniformly rounded or slightly convex. The posterior ridge is gently rounded, becoming flattened ventrally and somewhat biangular.

Taxonomy

Member of the mussel family Unionidae. It was originally described as Obliquaria cyphya Rafinesque. It has been placed in genera Obliquaria, Unio, Pleurobema, Margarita, and Margaron

Historical Range

Historically, the sheepnose occurred throughout much of the Mississippi River system with the exception of the upper Missouri River system and most lowland tributaries in the lower Mississippi River system. This species is known from the Mississippi, Ohio, Cumberland, Tennessee, and Ohio main stems, and numerous tributary streams rangewide. The sheepnose was historically known from 77 streams (including 1 canal) in 15 states (Minnesota, Wisconsin, Iowa, Illinois, Missouri, Ohio, West Virginia, Indiana, Kentucky, Tennessee, Alabama, Mississippi, Pennsylvania, Virginia, and Arkansas (see U.S. Fish and Wildlife Service, 2003)).

Current Range

Collectively, the last known and/or recent survey efforts have identified recruitment in 10 of the 25 populations (Appendix, Table 1). These 10 populations include the Mississippi River, Chippewa River, Meramec River, Ohio River, Allegheny River, Kanawha River, Green River, Tippecanoe River, Walhonding River, and Clinch River. These waterbodies occur within the Upper Mississippi River Basin, Ohio River Basin, and Tennessee River Basin. Evidence of recent recruitment has not been identified from the Lower Missouri River Basin or the Lower Mississippi River Basin (last identified from the Big Sunflower River in 2003). There is no known new extant populations since the publication of the final rule in 2012. However, proposed dam removals on the Green River and Walhonding River have the potential to result in sheepnose range expansion within these waterbodies. (USFWS, 2020)

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Unionids', with very few exceptions, life cycle includes a brief, obligatory parasitic stage on a host organism, typically fish.Eggs develop into microscopic larvae (glochidia) within special gill chambers of the female. The female expels the mature glochidia, which must attach to an appropriate host species to complete development. Following successful infestation, glochidia encyst (enclose in a cyst-like structure), remain attached to the host for several weeks, and then drop off as newly transformed juveniles. Plethobasus cyphyus is a short-termed brooder with ectobranchous marsupia. Gravid females have been found between May and July (Gordon and Layzer, 1989). Surber (1913) and Wilson (1916) found partially transformed glochidia on Stizostedion canadense (sauger) indicating that it serves as a glochidial host. Glochidia are released in conglutinates and mimic fish food organisms (Butler, 2003). New host fish confirmation from Watters et al. (2005): central stoneroller (Campostoma anomalum). Guenther et al. (2009) identified the following species as potential hosts for this mussel: blackspotted topminnow, blacktail shiner, bleeding shiner, bluntnose minnow, brassy minnow, bullhead minnow, central stoneroller, common shiner, eastern blacknose dace, fathead minnow, longnose dace, mimic shiner, Ozark minnow, pearl dace, red shiner, river shiner, silver chub, southern redbelly dace, spotfin shiner, steelcolor shiner, striped shiner, suckermouth minnow, western mosquitofish, whitetail shiner. Previously, the sauger (Sander canadensis) was identified as a natural host fish for the sheepnose mussel (Surber 1913, p. 110), with successful laboratory transformations on a few additional species (Watters et al. 2005, p. 11). Identified host fish for sheepnose have since expanded to 30 species (Jones et al. 2019, p. 205) (USFWS, 2020)

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: blackspotted topminnow, blacktail shiner, bleeding shiner, bluntnose minnow, brassy minnow, bullhead minnow, central stoneroller, common shiner, eastern blacknose dace, fathead minnow, longnose dace, mimic shiner, Ozark minnow, pearl dace, red shiner, river shiner, silver chub, southern redbelly dace, spotfin shiner, steelcolor shiner, striped shiner, suckermouth minnow, western mosquitofish, whitetail shiner, central stoneroller (Campostoma anomalum)

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Although it does inhabit medium-sized rivers, this mussel generally has been considered a large-river species. It may be associated with riffles and gravel/cobble substrates but usually has been reported from deep water (>2 m) with slight to swift currents and mud, sand, or gravel bottoms (Gordon and Layzer, 1989). It also appears capable of surviving in reservoirs, such as upper Chickamauga Reservoir immediately below Watts Bar Dam (Ahlstedt, 1989). Specimens in larger rivers may occur in deep runs (Parmalee and Bogan, 1998).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Unknown. Inferred from information (USFWS, 2020)

Species Trends:

Unknown. Inferred from information (USFWS, 2020)

Population Growth Rate:

unknown

Number of Populations:

37 Extant (USFWS, 2022)

Population Size:

2500 - 100,000 individuals

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

During historical times, it was fairly widespread in many Mississippi River system streams, although rarely very common. Archaeological evidence on relative abundance indicates it has been uncommon or rare in many streams for centuries. The sheepnose was last reported from some streams decades ago (e.g., Minnesota, Rock, Iowa, Illinois, Des Plaines, Fox, Mackinaw, Spoon, Castor, Little Sioux, Little Blue, Monongahela, Beaver, Scioto, Little Miami, Salt, Mississenewa, Vermilion, Embarras, White, Obey, Harpeth, North Fork Holston, French Broad, North Fork Clinch Rivers; Caney Fork) (Butler, 2003). According to Parmalee and Bogan (1998) and Neves (1991), the sheepnose has been extirpated throughout much of its former range or reduced to isolated populations. The last extant records for other streams are from several decades ago. The only records known from some streams are archeological specimens (e.g., Little Pigeon, Big Black, Yazoo Rivers; Saline Creek). It is extirpated from the Sangamon basin in Illinois (Schanzle and Cummings, 1991). Branson (1966) recorded it (valves only) from the Spring River in Missouri and alive in the Spring River in Kansas. It occurred historically across northern Alabama but now remains below Guntersville and Wilson Dams only (Williams et al., 2008). Sharp declines in population densities (50 to 70 percent) have been noted and it is a very rare component of the fauna when present. Densities of 0.03 - 0.02 mussels/square meter (Jenkinson and Ahlstedt, 1988) are representative of surviving populations. Very rarely are more than a few individuals found at a particular site. Increasing rarity has been noted by qualitative sampling and by absence from commercial shell harvests. The sheepnose has been eliminated from two-thirds of the total number of streams from which it was historically known (25 streams currently occupied compared to 77 streams historically). This species has also been eliminated from long reaches of former habitat including thousands of miles of the Mississippi, Wisconsin, Illinois, Ohio, Cumberland, and Tennessee Rivers and dozens of other streams and stream reaches. Of the 25 sheepnose populations that are considered extant, 9 are thought to be stable and 8 are considered declining (Table 2). Six other populations (Walhonding, Rock, Gasconade, Muskingum, Osage Fork, and Duck Rivers) are considered extant, but the status of these populations is unknown. Currently, populations are considered to be declining in 4 streams, stable in 8 streams, stable to increasing in 2 streams, and unknown in 11 streams (Appendix, Table 1) (USFWS, 2020). Sheepnose is currently known to occupy portions of 37 HUC8s, though it was historically found in an estimated 126 HUC8s (Figure 4.1, Table 4.2). Although sheepnose populations have decreased over time, the species continues to be found in all 14 States of its historic range. We evaluated demographic (Table 4.3) and risk (Table 4.4) factors for the 37 populations we consider extant and from where available data documented the collection of live or fresh dead specimens within the last 20 years (2000-2020) (USFWS, 2022).

Threats and Stressors

Stressor: Impoundments

Exposure:
Response: alter water quality and flow, impair habitats and increase fragmentation and isolation of mussel populations; creates habitat for invasive zebra mussels
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Dams eliminate or reduce river flow within impounded areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, decrease habitat heterogeneity, affect normal flood patterns, and block upstream and downstream movement of species (Layzer et al. 1993, pp. 68–69; Neves et al. 1997, pp. 63–64; Watters 2000, pp. 261–264). Within impounded waters, decline of freshwater mollusks has been attributed to sedimentation, decreased dissolved oxygen, and alteration in resident fish populations (Neves et al. 1997, pp. 63–64; Pringle et al. 2009, pp. 810–815; Watters 2000, pp. 261–264). Dams significantly alter downstream water quality and habitats (Allen and Flecker 1993, p. 36), and negatively affect tailwater mussel populations (Layzer et al. 1993, p. 69; Neves et al. 1997, p. 63; Watters 2000, pp. 265–266). Below dams, including those operated to generate hydroelectric power, mussel declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Layzer et al. 1993, p. 69; Neves et al. 1997, pp. 63–64; Pringle et al. 2009, pp. 810–815; Watters 2000, pp. 265–266; Williams et al. 1992, p. 7). Dam construction has a secondary effect of fragmenting the ranges of aquatic mollusk species, leaving relict habitats and populations isolated by the structures. These isolated populations are unable to naturally recolonize suitable habitat that is impacted by temporary, but devastating events, such as severe drought, chemical spills, or unauthorized discharges (Cope et al. 1997, pp. 235–237; Layzer et al. 1993, pp. 68–69; Miller and Payne 2001, pp. 14–15; Neves et al. 1997, pp. 63–75; Pringle et al. 2009, pp. 810–815; Watters 2000, pp. 264–265, 268; Watters and Flaute 2010, pp. 3–7).

Stressor: Channelization
Exposure:
Response: continued maintenance of channelized waterways
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Individuals are buried and/or incidentally relocated to disposal site of dredge material (i.e., unsuitable habitat).

Stressor: Contaminants
Exposure:
Response: reduce filtration efficiency, decrease growth and reproduction and induce behavioral changes
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Small populations of spectaclecase are vulnerable to the threat of detrimental chemical spills. Furthermore, exposure of mussels to low but ubiquitous concentrations of contaminants may not be immediately lethal but can reduce filtration efficiency, decrease growth and reproduction and induce behavioral changes in all life stages over time.

Stressor: Mining
Exposure:
Response: effects of water quality and habitat impairments; increase in siltation, change the hydrology
Consequence: Individuals die or cannot reproduce; populations become extirpated

Narrative: In-stream sand and gravel mining represents an imminent threat of moderate to high magnitude to the spectaclecase due to the effects of water quality and habitat impairments. Coal, oil and gas mining are a threat because these activities can cause increase in siltation, change the hydrology and alter water quality. Similarly, heavy metal contaminated sediments associated with lead mining have negatively impacted mussel populations along several miles of the Big River, Missouri (Roberts et al. 2009, p. 20).

Stressor: Sedimentation
Exposure:
Response: reduce feeding and respiratory efficiency; vector for chemical contaminants
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Excess sedimentation is considered an imminent threat of high magnitude to the spectaclecase because it can reduce feeding and respiratory efficiency of these species. Furthermore, sediments can be a vector for chemical contaminants.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Point source discharges within the range of the spectaclecase have been reduced since the inception of the Clean Water Act (33 U.S.C. 1251 et seq.), but this may not provide adequate protection for filter feeding organisms that can be impacted by extremely low levels of contaminants. There is no specific information on the sensitivity of the spectaclecase to common industrial and municipal pollutants, and very little information on other freshwater mussels. Therefore, it appears that a lack of adequate research and data prevents existing regulations, such as the Clean Water Act (administered by the EPA and the Corps), from being fully used or effective. The U.S. Army Corps of Engineers retains oversight authority and requires a permit for gravel-mining activities that deposit fill into streams under section 404 of the Clean Water Act. Additionally, a Corps permit is required under section 10 of the Rivers and Harbors Act (33 U.S.C. 401 et seq.) for navigable waterways including the lower 50 miles (80 km) of the Meramec River. However, many gravel-mining operations do not fall under these two categories.

Stressor: Small Isolated Populations
Exposure:
Response: Cannot adapt; Cannot rebound from population declines
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: The patchy distributional pattern of populations in short river reaches makes them much more susceptible to extirpation from single catastrophic events, such as toxic chemical spills (Watters and Dunn 1995, p. 257). Furthermore, this level of isolation makes natural repopulation of any extirpated population virtually impossible without human intervention. In addition, the fish host of spectaclecase is unknown; thus, propagation to reestablish the species in restored habitats and to maintain non-reproducing populations and focused conservation of its fish host are currently not possible. Population isolation prohibits the natural interchange of genetic material between populations, and small population size reduces the reservoir of genetic diversity within populations, which can lead to inbreeding depression (Avise and Hamrick 1996, p. 461). Despite any evolutionaryadaptations for rarity, habitat loss and degradation increase a species' vulnerability to extinction (Noss and Cooperrider 1994, pp. 58 - 62). Numerous authors (e.g., Noss and Cooperrider 1994, pp. 58 - 62, Thomas 1997, p. 373) have indicated that the

probability of extinction increases with decreasing habitat availability. Recruitment reduction or failure is a threat for many small spectaclecase populations range wide, a condition exacerbated by reduced range and increasingly isolated populations (Butler 2002, p. 28). If these trends continue, further significant declines in total spectaclecase population size and consequent reduction in long-term viability may soon become apparent.

Stressor: Exotic Species
Exposure:
Response: impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, and locally depleting food resources and increasing waste products; eats spectaclecase
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: The exotic species that poses the most significant threat to the spectaclecase is the zebra mussel. Zebra mussels impact native mussels primarily through direct fouling of the shells of live native mussels. Zebra mussels attach in large numbers to the shells of live native mussels and are implicated in the loss of entire native mussel beds. Fouling impacts include impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, and locally depleting food resources and increasing waste products. Heavy infestations of zebra mussels on native mussels may overly stress the animals by reducing their energy stores. Zebra mussels may also reduce food concentrations to levels too low to support reproduction, or even survival in extreme cases. The spectaclecase's colonial tendency could allow for very large numbers to be affected by a single favorable year for zebra mussels. Zebra mussels are established throughout the upper Mississippi, lower St. Croix, Ohio, and Tennessee Rivers, overlapping much of the current range of the spectaclecase. The black carp (Mylopharyngodon piceus) is a potential threat to the spectaclecase (Strayer 1999, p. 89); it has been introduced into North America since the 1970s. Black carp are known to eat clams (Corbicula spp.) and unionid mussels and snails. Several other Asian carp species, which may disrupt aquatic food chains, are present in the some of the rivers with extant spectaclecase populations (e.g., Mississippi River, Chick and Pegg 2001, pp. 2250-2251, Amberg et al. 2013, pp. 4 - 15).

Stressor: Cimate change
Exposure:
Response:
Consequence: Individuals die or cannot reproduce; populations become extirpated
Narrative: Understanding the effects of climate change on freshwater mussels is of crucial importance, because the extreme fragmentation of freshwater drainage systems, coupled with the limited ability of mussels to migrate, will make it particularly difficult for mussels to adjust their range in response to changes in climate (Strayer 2008, p. 30). For example, changes in temperature andprecipitation can increase the likelihood of flooding or increase drought duration and intensity, resulting in direct impacts to freshwater mussels (Hastie et al. 2003, pp. 40 - 43, Golladay et al. 2004, p. 503). Riverine mussel distribution appears to be highly dependent on complex hydrological characteristics (e.g., Morales et al. 2006, pp. 669 - 673, Zigler et al. 2008, p. 358).Climate change currently represents a non-imminent threat that may become a future threat of high magnitude to the spectaclecase due to the limited ability of their fragmented populations to migrate.

Recovery

Reclassification Criteria:
Not available

Recovery Priority Number: 11

Delisting Criteria:
Not available

Recovery Actions:

- Maintain high quality habitat, consisting of flowing water sites in medium-to-large rivers with good water quality (new national wildlife refuge on Clinch River planned; modified reservoir releases from some dams to improve water quality may allow for potential reintroduction). 2) Monitor and regulate land use upstream to minimize erosion of silt to rivers. Maintain ongoing conservation outreach program focused on the St. Croix River and its mussel fauna. 3) Relocation of a mussel communities can be used to minimize the impact of specific development-related projects (e.g., highway crossings, channel dredging, mooring cells) on important mussel resources, including listed species. Biological Research Needs: Determine habitat preferences and environmental tolerances, particularly tolerance to various pollutants and siltation. Research is needed on reproductive biology, and identification of glochidial hosts. Life history studies need to be done to identify age and size at sexual maturity, recruitment success, age class structure, and other important life history parameters.

Conservation Measures and Best Management Practices:

- New Recovery Priority Number: A Recovery Priority Number (RPN) was not assigned to the species prior to this 5-year review. Following this review, we recommend a RPN of 11 on a scale of 1(C) (highest) to 18 (lowest). A RPN of 11 indicates this species faces a moderate degree of threat, and is considered to have a low (to moderate) recovery potential. The moderate degree of threat is based on the fact that although threats are numerous, long-standing, and ongoing, they and their management techniques are fairly well understood. The decline of the sheepnose (described by Butler 2002 and 77 FR 14914) is primarily the result of habitat loss and degradation (Neves 1991, p. 252) due to impoundments, channelization, chemical contaminants, mining, and sedimentation, among other stressors (Neves 1991, p. 252, Neves 1993, pp. 4 - 6, Williams et al. 1993, pp. 7 - 9, Neves et al. 1997, pp. 60, 63 - 75, Watters 2000, pp. 262-267). These stressors have had profound impacts on sheepnose populations and their habitat for decades. Although we have a general understanding of these threats and stressors and their associated management approaches, the recovery potential of the species is considered to be moderate to low due to the limited ability to reduce impacts from some prominent threats. For example, the reconnection of some isolated populations through the removal of impoundments is impeded as a result of the necessity to maintain navigable waters. Further, many applicable management and conservation techniques would require long-term and intensive management. (USFWS, 2020)
- 4.0 RECOMMENDATIONS FOR NEAR TERM ACTIONS • Develop a recovery plan for the species. • Perform surveys in known streams to assess the status of known populations and search for additional populations in appropriate habitat to evaluate their potential role in the recovery strategy. • Continue genetics research (for example, expansion of the Schwarz and Roe (2018) study, Section 2.3.1.1) to further assess and refine population structures within the remaining occupied streams throughout the species' range and inform recovery planning. • Rear juveniles (head-

starting) in captivity using host fish and in-vitro techniques for future augmentation and reintroductions and develop a captive propagation, genetics management, and reintroduction plan to inform recovery efforts. • Investigate potential sites for future augmentation or reintroduction of captivity reared/head-started juveniles and/or adults. • Develop and implement a monitoring program to evaluate conservation efforts, monitor population levels and habitat conditions, and assess the long-term viability of extant, newly discovered, augmented, and reintroduced sheepnose populations. • Maintain and increase vegetated riparian buffers of streams throughout the range of the species. • Initiate watershed-level, community based riparian habitat restoration projects in rivers with sheepnose or upstream in the watersheds harboring the sheepnose. • Investigate U.S. Environmental Protection Agency's water quality criteria for pollutants to determine levels that would be protective of sheepnose and other mussels. (USFWS, 2020)

- Conservation Measures: The recent removal of Green River Lock and Dam 6 (KY) along with the planned removal of Lock and Dam 5 on the Green River (KY) and the Six Mile Dam on the Walhonding River (OH) may provide for range expansion within these systems (ESI 2017, p. 10; ESII 2019, p. 6-11; A. Boyer, USFWS, pers. comm. 2020). Additionally, these dam removals will likely facilitate movement of the sheepnose's native host fish species. Refer to Section 2.3.1.2 for additional discussion. Section 7 consultation was completed in 2016, for activities associated with the construction of a new I-74 bridge within Pool 15 of the Mississippi River and demolition of the existing bridge, including a large-scale mussel relocation (refer to Section 2.3.1.2). As part of the mussel relocation, long-term studies are being conducted to assess the success of sheepnose mussel relocations, including individual survival, growth and movement post-relocation (ESI, 2018, p. 22). The first monitoring events of the relocation sites within Pool 15 of the Upper Mississippi River took place in 2017 and 2018. Monitoring of the relocation areas will continue in the years 2020, 2023, and 2026. The results of this study may help improve and inform and increase survival of future sheepnose relocation, translocation, stocking, and reintroduction efforts. The identification of additional host fish species and ideal propagation conditions through laboratory trials, including fish holding temperatures and techniques for identifying the reproductive condition of gravid sheepnose females, will help promote increased juvenile production through propagation efforts (Hove et al. 2015). New knowledge regarding the identification of genetically isolated sheepnose populations, genetic diversity within sheepnose populations and sub-populations and the gene flow in-between suggests management efforts should focus onreestablishing connections between sub-populations to increase and maintain genetic diversity (Schwartz and Roe 2018, p. 39). The maintenance of genetic variability within populations and sub-populations may be further supported through propagation and reintroduction efforts throughout the species' current and historical range (Schwartz and Roe 2018, p. 39). The Service will be cooperating with state, federal, and local agencies, universities, and other partners, beginning in 2020-2021, to develop and implement a propagation and reintroduction plan for this species in order to comply with the Service's controlled propagation policy. As such, we will be using the International Union for Conservation of Nature (IUCN) guidelines to facilitate our assessment of ecological, social, and economic risks, and to aid development of collection, release, and monitoring strategies. Reintroducing populations to former parts of the species' historical range has the potential to increase redundancy by adding new populations and will help to mediate the effects of habitat fragmentation. For example, the Illinois River (extirpated) provides a linkage between the Kankakee and Mississippi River populations and has experienced water quality and biological condition improvements since enactment of the Clean Water Act (1972), resulting in this stream being a potential candidate for reintroduction following further assessment. Dispersing to new locations may also help mediate effects of zebra mussels, particularly if reintroductions take place in areas where the threat of zebra mussels or other invasive species are low. Augmenting existing populations will make populations more resilient to stochastic events and may help address the threat of small population genetics. (USFWS, 2020)

References

Final Listing Rule

USFWS. 2020. Sheepnose (Plethobasus cyphyus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Region 3 Illinois – Iowa Ecological Services Field Office. Moline, Illinois. 32 pp.

Final Rule and NatureServe. USFWS. 2020. Sheepnose (Plethobasus cyphyus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Region 3 Illinois – Iowa Ecological Services Field Office. Moline, Illinois. 32 pp.

Final Rule and NatureServe

Final Listing Rule and NatureServe. USFWS. 2020. Sheepnose (Plethobasus cyphyus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Region 3 Illinois – Iowa Ecological Services Field Office. Moline, Illinois. 32 pp. USFWS. 2022. Species status assessment report for sheepnose (Plethobasus cyphyus). June 2022 (Version 1.0). Illinois-Iowa Ecological Services Field Office, Moline, Illinois.

nature serve

SPECIES ACCOUNT: *Pleurobema athearni* (Canoe Creek Clubshell)

Species Taxonomic and Listing Information

Commonly-used Acronym: CCC

Listing Status: Endangered

Physical Description

The CCC (Figure 2-1) is a medium sized mussel up to 97 mm in length, with a moderately thick shell, that is thickest anteriorly and thinnest posteriorly near the apertures (Gangloff et al. 2006, p. 48; Williams et al. 2008, p. 505; Fobian et al. 2017, p. 97). The shell outline is roughly ovate or sub-ovate, with slight sculpturing on the posterior-dorsal third of the valves (Gangloff et al. 2006, p 48). The periostracum of the shell is tawny to brown in color and without rays (Williams et al. 2008, p. 505), with dark yellow to faint green growth rests (a ridge formed during an intermediate stage of growth when this area was the edge of the shell) present on smaller individuals (< 40 mm) (Gangloff et al. 2006, p. 48). The nacre is also white, usually iridescent posteriorly (Gangloff et al. 2006, p 48). (USFWS, 2020)

Taxonomy

The CCC belongs to the Family Unionidae, also known as unionids, the naiads, and pearly mussels; a group of bivalve mollusks that have been in existence for over 400 million years and now representing over 600 species worldwide and nearly 300 in North America (Strayer et al. 2004, p. 429; Bogan and Roe 2008, p. 350; Lopes-Lima et al. 2018, p. 3; Williams et al. 2017, p. 33). This report on the CCC follows the most recently published and accepted taxonomic treatment of North American freshwater mussels as provided by Williams et al. (2017, entire). The currently accepted classification of the CCC (Williams et al. 2017, pp 35, 41) is: Kingdom: Animalia (Linnaeus, 1758) Phylum: Mollusca (Linnaeus, 1758) Class: Bivalvia (Linnaeus, 1758) Intraclass: Heteroconchia (Hertwig, 1895) Cohort: Uniomorphi (Gray, 1854) [=Paleoheterodonta] Order: Unionida (Gray, 1854) Superfamily: Unionoidea (Rafinesque, 1820) Family: Unionidae (Rafinesque, 1820) Subfamily: Ambleminae (Rafinesque, 1820) Tribe: Pleurobemini (Hannibal, 1912) Genus: Pleurobema (Rafinesque, 1819) Species: Pleurobema athearni (Gangloff, Williams, and Feminella, 2006) (USFWS, 2020)

Historical Range

Limited historical distribution data is available for the CCC due to only recently being described and the scarcity of previously vouchered individuals within museum collections (Gangloff et al. 2006, p. 47, MRBMRC 2010, p. 26). However the most recent comprehensive survey of BCC mussels (Fobian et al. 2017, pp. 26-29) verified the continued presence of CCC at historical locations (i.e., individuals vouchered in museum collections) (Gangloff et al. 2006, p. 47) and documented new range extensions within lower Little Canoe Creek (LCC-east) on the St. Clair and Etowah County line. (USFWS, 2020)

Current Range

The CCC is only known to occur within the BCC watershed in St. Clair and Etowah counties, Alabama (Gangloff et al. 2006, p. 53; Williams et al. 2008, p. 506). BCC is a western tributary of the Coosa River and encompasses 583 km2 (Wynn et al. 2016, p. 6). The BCC watershed is located in two physiographic provinces, the Cumberland Plateau in the north and the Alabama

Valley and Ridge to the south (Figure 2-2) (Wynn et al. 2016, p. 7). The BCC mainstem originates in the Ridge and Valley Physiographic Province near Springville, Shelby County, Alabama and flows northeast for 84 km before joining the Coosa River (H. Neely Henry Reservoir) on the St. Clair and Etowah County line, Alabama (Gangloff et al. 2006, p. 53; Wynn et al. 2016, p. 6-7). Historically BBC flowed unimpeded for another 15 km, prior to the impoundment of this reach, before reaching the Coosa River mainstem (Gangloff et al. 2006, p. 53). The CCC are currently known to be confined to 50.6 km of stream length within the BCC watershed. Survey records of CCC are known from 4.7 km of stream length in LLC (east) along the St. Clair/Etowah County line, within 31.3 km of the BCC mainstem, and 14.6 km within LCC (west), St. Clair County. Occupied habitat consists of survey data from the past 20 years (1999-2019), where live CCC or shell material (fresh dead, weathered dead, or relic shells) were documented. (USFWS, 2020)

Critical Habitat Designated

Yes; 8/5/2022.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine that the Canoe Creek clubshell (Pleurobema athearni), a freshwater mussel species endemic to a single watershed in north-central Alabama, is an endangered species under the Endangered Species Act of 1973 (Act), as amended. We also designate critical habitat for the species under the Act. In total, approximately 58.5 river kilometers (36.3 river miles) in St. Clair and Etowah Counties, Alabama, fall within the boundaries of the critical habitat designation. This rule extends the Act's protections to the species and its designated critical habitat. (USFWS, 2022)

Critical Habitat Designation

Unit 1: Little Canoe Creek East Unit 1 consists of 9.7 river km (6.0 river mi) of Little Canoe Creek East, due east of the Town of Steele, in St. Clair and Etowah Counties, Alabama. The unit consists of the Little Canoe Creek mainstem to the bankfull width from the intersection with the Federal Energy Regulatory Commission boundary of H. Neely Henry Reservoir (at elevation 155 meters (m) (509 feet (ft)) above mean sea level and approximately 4.4 river km (2.7 river mi) upstream of its confluence with Big Canoe Creek), upstream 9.7 river km (6.0 river mi) to the U.S. Highway 11 bridge crossing. This unit is currently occupied by the Canoe Creek clubshell. The majority of the adjacent land surrounding this unit is privately owned. A small amount of the adjacent land is publicly owned in the form of bridge crossings and easements, and portions of the eastern bank of Little Canoe Creek between U.S. Highway 11 to Interstate 59, in Etowah County, Alabama. Approximately 2.4 river km (1.5 river mi) of Little Canoe Creek borders property to the east owned by Etowah County, Alabama. Unit 1 contains all physical or biological features essential to the conservation of the species. The channel within Unit 1 is relatively stable and provides the necessary riffle-run-pool sequences required by the Canoe Creek clubshell. A continued hydrologic flow regime with adequate water quality and limited fine sediments are present within this unit, providing habitat features that support the Canoe Creek clubshell. The unit also contains fish hosts for the clubshell. The physical and biological features in this unit may require special management considerations or protections to ensure that conditions do not further degrade. Examples of threats within this unit include excessive amounts of fine sediment deposited in the channel, changes in water quality (impairment), activities that cause a destabilization of the stream channel and/or its banks, loss of riparian cover, and altered hydrology from either inundation, channelization, withdrawals, or flow loss/scour resulting from other humaninduced perturbations (see Special Management Considerations or Protection, above). Unit 2: Big Canoe Creek/Little Canoe Creek West Unit 2 consists of 48.8 river km (30.3 river mi) of Big Canoe Creek and its tributary Little Canoe Creek West, which are located geographically between the cities of Springville and Ashville, St. Clair County, Alabama. The unit consists of the main channel of Big Canoe Creek to the bankfull width from the Double Bridge Road bridge crossing near Ashville, Alabama, upstream 32.2 river km (20.0 river mi) to the Washington Valley Rd (St. Clair County Road 23) bridge crossing near Springville, Alabama; and Little Canoe Creek West from its confluence with Big Canoe Creek, upstream 16.6 river km (10.3 river mi) to the confluence of Stovall Branch. This unit is currently occupied by the Canoe Creek clubshell. The majority of this unit is adjacent to private land, except for any small amount of adjacent land that is publicly owned in the form of bridge crossings and easements. Unit 2 contains all physical or biological features essential to the conservation of the species. The channel within Unit 2 is relatively stable and provides the necessary riffle-run-pool sequences required by the Canoe Creek clubshell. A continued hydrologic flow regime with adequate water quality and limited fine sediments is present within this unit, providing habitat features that support the Canoe Creek clubshell. A diverse fish fauna, including fish hosts for the clubshell, are known from this unit. The physical and biological features in this unit may require special management considerations or protections to ensure that conditions do not degrade. Examples of threats within this unit include excessive amounts of fine sediment deposited in the channel, changes in water quality (impairment), activities that cause a destabilization of the stream channel and/or its banks, loss of riparian cover, and altered hydrology from either inundation, channelization, withdrawals, or flow loss/scour resulting from other humaninduced perturbations (see Special Management Considerations or Protection, above). (USFWS, 2022)

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of the Canoe Creek clubshell consist of the following components:

(i) Suitable substrates and connected instream habitats, characterized by a geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without aggrading or degrading bed elevation) and connected instream habitats (such as stable riffle-run-pool habitats that provide flow refuges consisting of siltfree gravel and coarse sand substrates).

(ii) A hydrologic flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species is found; to maintain connectivity of streams with the floodplain; and to provide for normal behavior, growth, and survival of all life stages of Canoe Creek clubshell mussels and their fish hosts.

(iii) Water quality (including, but not limited to, temperature, conductivity, hardness, turbidity, ammonia, heavy metals, oxygen content, and other chemical characteristics) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages of Canoe Creek clubshell mussels and their fish hosts.

(iv) Sediment quality (including, but not limited to, coarse sand and/or gravel substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics) necessary for normal behavior, growth, and viability of all life stages of Canoe Creek clubshell mussels and their fish hosts.

(v) The presence and abundance of fish hosts, which may include the tricolor shiner (Cyprinella trichroistia), Alabama shiner (C. callistia), and striped shiner (Luxilus chrysocephalus), necessary for recruitment of the Canoe Creek clubshell mussel.

Life History

Food/Nutrient Resources

Food Source

Adult: algae, bacteria, detritus, and microscopic animals (USFWS, 2020)

Food/Nutrient Narrative

Adult: Mussels are omnivores and their diet consists of a wide variety of particulate material (primarily less than 20 µm in size), including algae, bacteria, detritus, and microscopic animals (Gatenby et al. 1996, p. 606; Haag 2012, p. 26). It has also been surmised that dissolved organic matter may be a significant source of nutrition (Vaughn et al. 2008, p. 411). Such an array of foods, containing essential long-chain fatty acids, sterols, amino acids, and other biochemical compounds, may be necessary to supply total nutritional needs (Strayer et al. 2004, p. 431). (USFWS, 2020)

Reproductive Strategy

Adult: broadcast spawner

Lifespan

Adult: (estimated at 25 to 35 years, but possibly up to 50 years given its large size) (USFWS, 2022).

Breeding Season

Adult: Gravid Canoe Creek clubshell have been collected in May and June (USFWS, 2022).

Key Resources Needed for Breeding

Adult: Host fish

Reproduction Narrative

Adult: The CCC has a complex life cycle that relies on fish hosts for successful reproduction, similar to other mussels. In general, mussels are either male or female (Haag 2012, p. 37). Males release sperm into the water column, which is taken in by the female through the incurrent aperture (Figure ES-2), where water enters the mantle cavity. The sperm fertilizes eggs that are held within the female's gills in the marsupial chamber. The developing larvae remain in the gill chamber until they mature (called glochidia) and are ready for release. (See Figure 2-5 for a generalized freshwater mussel life cycle.) Freshwater mussels such as the CCC have a complex life history involving an obligate parasitic larval life stage, which are wholly dependent on a suitable host fish (Haag 2012, pp. 38-41). The CCC is believed to be tachytictic (a short-term brooder) and gravid in spring and summer, similar to other Pleurobema species (Williams et al. p. 506; MRBMRC 2010, p. 26; Gangloff et al. 2006, p. 47). Gravid CCC have been collected from LCC (east) in May and June (2019), with water temperatures between 16.5-22.0 degrees Celsius (°C) (Fobian 2019, p. 10). Similar to other species in the tribe Pleurobemini, the CCC targets drift-feeding minnow species (e.g., members of Cyprinidae) as their host fish by releasing glochidia contained in packets called conglutinates (Figure 2-1) (Haag 2012, p. 163); more specifically, pelagic conglutinates (Haag 2012, p. 148; Williams et al. 2008, p. 506) (Figure 2-1). A host trial was conducted for the CCC in May-June 2019, and identified the tricolor shiner (Cyprinella trichroistia), Alabama shiner (C. callistia) as primary hosts with metamorphosis rates of 78.5 and 73.6, respectively (Fobian 2019, pp. 6, 14). Eight other species of fish were determined to be marginal hosts. Striped shiner (Luxilus chrysocephalus) had the best metamorphosis rate (34.6%) of the marginal hosts (Fobian 2019, pp. 6, 14); while the others: stoneroller (Campostoma oligolepis), Coosa shiner (Notropis xaenocephalus), silverstripe shiner (N. stilbius), longear sunfish (Lepomis megalotis), bronze darter (Percina palmaris), fathead minnow (Pimephales promelas), and golden shiner (Notemigonus cysoleucas); had less than 7% metamorphosis (Fobian 2019, pp. 6, 14). Juvenile CCC were recovered from host fish during this trial between 10 to 25 days post glochidial attachment to fish with peak juvenile recovery occurring at 19 days post-inoculation (Fobian 2019, pp. 6). (USFWS, 2020)

Habitat Type

Adult: Rivers/Streams (USFWS, 2020)

Environmental Specificity

Adult: Narrow

Habitat Narrative

Adult: The CCC is found primarily in shoal habitat and prefers gravel substrates (Williams et al. 2008, p. 506). CCC habitat includes rivers and streams with natural flow regimes within the BCC watershed. While many mussels can survive seasonally low flows and periodic short-term drying events, intermittent stream habitats generally cannot support mussel populations. (USFWS, 2020)

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Mussels are generally immobile but experience their primary opportunity for dispersal and movement within the stream as glochidia attached to a mobile host fish (Smith 1985, p. 105). Even though, movement of the family Cyprinidae (shiners and minnows) (CCC's likely host) is relatively small (Radinger and Wolter 2014, p. 461). An example of distance moved by a member of that family was documented in a study of movement patterns by the blue shiner (Cyprinella caerulea). During that study, the blue shiner moved an average distance of just 130.7 meters with the longest distance moved by that species during the study, 332 meters (Johnston 2000, pp. 170, 174). After being transported by the host fish,the newly transformed juveniles drop to the substrate on the bottom of the stream. Those juveniles that drop in unsuitable substrates die because their immobility prevents them from relocating to more favorable habitat. Juvenile freshwater mussels burrow into interstitial substrates and grow to a larger size that is less susceptible to predation and displacement from high flow events (Yeager et al. 1994, p. 220). Adult mussels typically remain within the same general location where they are dropped off (excysted) of their host fish as juveniles. (USFWS, 2020)

Population Information and Trends

Number of Populations:

2 (USFWS, 2020)

Population Narrative:

The CCC is a narrow endemic within the Big Canoe Creek (BCC) (0315010603) Hydrologic Unit Code (HUC) 10 (U.S. Geological Survey) watershed and is comprised of two subpopulations: Subpopulation West (Figure 2-6) and Subpopulation East (Figure 2-7). Subpopulation West includes the Middle Big Canoe Creek (031501060305), Upper Big Canoe Creek (031501060303), Headwaters Big Canoe Creek (031501060302), and Little Canoe Creek (031501060301) HUC 12 Units in St. Clair County, Alabama (Figure 2-6). Subpopulation East includes the Lake Sumatanga-Little Canoe Creek (031501060304) HUC 12 unit in Etowah and St. Clair Counties, Alabama (Figure 2-7). (USFWS, 2020) The CCC is also known to occur within approximately 5 km of Little Canoe Creek (east) due east of Steele, Alabama (along the St. Clair and Etowah County line). In total, the CCC is extant in less than 52 km of river within the BCC watershed. Two subpopulations were delineated using Hydrologic Unit Code (HUC) 12 watershed boundaries and tributaries leading to the Coosa River (Neely Henry Reservoir) (Figure ES-1), which includes a western subpopulation near Springville and Ashville and an eastern subpopulation near Steele. The two subpopulations are isolated from one another by a stretch of unsuitable habitat, and as a result, no genetic exchange is believed to be occurring between these two subpopulations. (USFWS, 2020)

Threats and Stressors

Stressor: Climate Change (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative:

Stressor: dams and other aquatic barriers (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: The fragmentation of river habitat by dams and other aquatic barriers (e.g., perched or undersized culverts) is one of the primary threats to aquatic species in the U.S. (Martin and Apse 2014, p. 7). Dams (whether man-made or nature-made (e.g., from beavers (Castor canadensis) or wind thrown debris)) have a profound impact on in-stream habitat as they can change lotic systems (flowing water) to lentic systems (stationary or relatively still water). Moreover, fragmentation by dams or culverts generally involves loss of access to quality habitat for one or more life stages of freshwater species. In the case of mussels, fragmentation can result in barriers to host fish movement, which in turn, may influence mussel distributions. Mussels that use small host fishes such as darters (family Percidae) and minnows (family Cyprinidae), are more susceptible to impacts from habitat fragmentation due to increasing distance between suitable habitat patches and low likelihood of small host fish swimming over that distance as compared to large host fishes (Vaughn 2012, p. 7). Barriers to movement can cause isolated or patchy distributions of mussels, which may limit both genetic (USFWS, 2020)

Stressor: Sedimentation (87 FR, 40119)
Exposure:

Response:
Consequence:
Narrative: Under a natural flow regime, sediments are washed through river and stream systems, and the overall amount of sediment in the substrate remains relatively stable over time. However, some past and ongoing activities or practices can result in elevated levels of sediment in the substrate. This excessive stream sedimentation (or siltation) can be caused by soil erosion associated with upland activities (e.g., agriculture, poor forest management practices, unpaved roads, road construction, development, unstable streambanks, and urbanization) and stream channel destabilization associated with other activities (e.g., dredging, poorly installed culverts, pipeline crossings, or other instream structures) (Brim Box and Mossa 1999, p. 102; Wynn et al. 2016, pp. 36–52). In severe cases, stream bottoms can become ‘‘embedded,’’ whereby substrate features including larger cobbles, gravel, and boulders are surrounded by, or buried in, sediment, which eliminates interstitial spaces (small openings between rocks and gravels) (87 FR, 40119).

Stressor: Water Quality (87 FR, 40119)
Exposure:
Response:
Consequence:
Narrative: Water quality in freshwater systems can be impaired through contamination or alteration of water chemistry. Chemical contaminants are ubiquitous throughout the environment and are a major reason for the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Chemicals such as ammonia enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal effluents, and agricultural runoff. These sources contribute organic compounds, heavy metals, pesticides, herbicides, and a wide variety of newly emerging contaminants to the aquatic environment (87 FR 40119.

Stressor: Climate Events (87 FR 40119)
Exposure:
Response:
Consequence:
Narrative: Climate events such as droughts and floods can have significant impacts on freshwater systems and their fundamental ecological processes (Poff et al. 2002, pp. ii–v). Drought can cause dewatering of freshwater habitats and low flows, which exacerbate water quality impairments (e.g., dissolved oxygen, temperature, contaminants). Streams with smaller drainage areas are especially vulnerable to drought because they are more likely to experience extensive dewatering than larger streams that maintain substantial flow (Haag and Warren 2008, pp. 1172–1173). Floods can cause excessive erosion, destabilize banks and bed materials, and lead to increases in sedimentation and suspended solids. Climate change can affect the frequency and duration of drought and floods, as well as alter normal temperature regimes. Higher water temperatures, which are common during the low flow periods of droughts, decrease mussel survival (Gough et al. 2012, p. 2363). Severe drought and major floods can have significant impacts on mussel communities (Haag and Warren 2008, p. 1165; Hastie et al. 2001, p. 107; Hastie et al. 2003, pp. 40–45). Reduced flows from drought can isolate or eliminate areas of suitable habitat for mussels in all life stages and render individuals exposed and vulnerable to drying and predation (Golladay et al. 2004, pp. 503–504). Drought can also degrade water quality (e.g., decreased dissolved oxygen levels and increased temperatures), which can reduce mussel survival, reproduction, and fitness (Golladay et al. 2004, p. 501; Haag and Warren 2008, pp.

1174–1176) (see discussion above under ‘‘Water Quality’’). If severe or frequent, droughts can cause substantial declines in mussel abundance. Flooding can also affect mussels by dislodging individuals and depositing them in unsuitable habitat, which can affect their ability to survive and reproduce (Hastie et al. 2001, pp. 108, 114). Higher turbidity and reduced visibility during high flows reduce the chances of successful fertilization of the female and impede the host fish’s ability to find and take up conglutinates (87 FR 40120)

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2020. Species Status Assessment Report for the Canoe Creek Clubshell (Pleurobema athearni), Version 1.1. February 2020. Atlanta, GA.

USFWS. 2022. Endangered and Threatened Wildlife and Plants

Endangered Species Status for the Canoe Creek Clubshell and Designation of Critical Habitat. Final Rule. FR Vol 87, No 128. Pages 40115-40138.

USFWS. 2020. Species Status Assessment Report for the Canoe Creek Clubshell (Pleurobema athearni), Version 1.1. February 2020. Atlanta, GA. USFWS. 2022. RECOVERY OUTLINE for Canoe Creek Clubshell (Pleurobema athearni). Alabama Ecological Services Field Office.

87 FR. 40115-40138. Endangered and Threatened Wildlife and Plants

Endangered Species Status for the Canoe Creek Clubshell and Designation of Critical Habitat. Final Rule.

SPECIES ACCOUNT: *Pleurobema clava* (Clubshell)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 01/22/1993, 06/14/2001; Northeast Region (R5), Southeast Region (R4) (USFWS, 2016)

Physical Description

A small (up to 2 inches), thick, freshwater mussel with a tan colored shell with green rays. The animal is white to pale orange. It is 9 cm long (NatureServe, 2015).

Taxonomy

The clubshell was described by Lamarck in 1819 as Unio clava, from a specimen sent to him labeled “Lake Erie.” (USFWS, 1994). The relationship between Pleurobema oviforme and Pleurobema clava is a matter of debate as P. oviforme replaces P. clava in headwaters of the Tennessee River, and it has been suggested that they are conspecific (Williams et al., 2008) (NatureServe, 2015).

Historical Range

Historically, it was distributed across nine states in the Wabash, Ohio, Kanawha, Kentucky (Danglade, 1922; Clarke, 1987), Green, Monongahela, and Allegheny Rivers and their tributaries (NatureServe, 2015).

Current Range

It is currently known from 12 streams in six states: Tippecanoe River in Indiana; Fish Creek in Ohio and Indiana; West Branch of the St. Josephs River in Ohio and Michigan; Walhonding River in Ohio; East Fork of the West Branch of the St. Josephs River in Michigan; Little Darby Creek in Madison County, Ohio; French Creek in Pennsylvania, in small numbers in the Green River in Kentucky, and the Elk River and Hackers Creek of the West Fork River in West Virginia (USFWS, 1994) (NatureServe, 2015).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Clubshell glochidia are obligate parasites on fish gills. The striped shiner (Notropis chrysocephalus), central stoneroller (Campostoma anomalum), blackside darter (Percina maculata), and logperch (Percina caprodes) have been capable of serving as hosts for the clubshell under laboratory conditions (Watters and O'Dee 1997, O'Dee and Watters 2000). It is likely that additional untested fish species can be used by clubshell glochidia in the wild (USFWS, 2009). The glochidia clamp down on the host tissue, and cause cells to lyse. This fluid forms part of the food for the developing parasite (Arey 1924b, 1932b; Blystad 1924) (USFWS, 1994).

Juvenile: Yeager et at. (1993) believed food for juveniles consisted of interstitial bacteria, yet an algal mix plus silt was suggested as food by Humphrey and Simpson (1985) and Gatenby el al. (1993) (USFWS, 1994).

Adult: Freshwater mussels are filter-feeding animals. Allen (1914) found the gut to contain mostly diatoms and other algae, and in 1921 suggested that mussels feed on bacteria, protozoans, and organic particles. Churchill and Lewis (1924) agreed with Allen, finding that diatoms passed through the digestive system intact. Fikes (1972) maintained Amblema plicata for five months using an alga as food, but Imlay and Paige (1972) suggested that mussels fed on bacteria, protozoans, and the by-products of other food (such as fish food), rather than on the food itself (USFWS, 1994).

Reproduction Narrative

Larvae: Minute bivalved larvae, or glochidia, develop over a period of days to months. Estimated chances of a glochidium surviving to transform and excyst range from 0.0001% (Jansen and Hanson 1991) to 0.000001% (Young and Williams 1984) (USFWS, 1994).

Juvenile: The clubshell has low annual juvenile survival rates (USFWS, 2009).

Adult: Virtually nothing is known specifically for Pleurobema clava. Based upon counts of annular growth lines, Pleurobema clava may reach 30+ years of age (NatureServe, 2015). The clubshell likely reaches sexual maturity between 3 and 5 years, as does the closely related Tennessee clubshell (Weaver et al. 1991). Males of the genus Pleurobema release sperm into the water in April, May, and June, and downstream females uptake the sperm with incoming water (Weaver et al. 1991) (USFWS, 2009). Generally there is only one breeding season a year (USFWS, 1994).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, impoundments, water depth > 10 m (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (NatureServe, 2015)

Habitat Narrative

Adult: Despite the type locality of Lake Erie (apparently in error), this is a species of small to medium-sized rivers and streams. Ortmann (1919) remarked that it was "a rare shell, and never found in great numbers. It is found mostly in sand and fine gravel, and is deeply buried." Hoggarth (pers. comm.) and Watters (unpublished) have found live individuals completely buried with the posterior shell margin facing up in sand/gravel substrate in riffle/run situations in less than 1.5 feet of water. This seems to be the habitat of choice. Because it buries itself beneath the substrate, it is rarely found alive even in places where it is believed to occur in some numbers. Although now considered a creek or small river species, many records from larger rivers such as the Wabash and Tennessee show that this is a recent misconception. This species is generally found in clean, coarse sand and gravel in runs, often just downstream of a riffle, and cannot tolerate mud or slackwater conditions (USFWS, 1994). The environmental specificity is moderate (generalist or community with some key requirements scarce). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Larvae: Low (USFWS, 2009)

Adult: Low (USFWS, 1994)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Larvae: Moderate (inferred from USFWS, 2009)

Dispersal/Migration Narrative

Larvae: Parasitism is a possible adaptation for upstream dispersal of a relatively immobile organism (USFWS, 2009). Liberated glochidia may travel miles downstream in currents (Clark and Stein 1921) (USFWS, 1994).

Adult: This species is non-migratory (NatureServe, 2015). Freshwater mussels are essentially immotile animals (USFWS, 1994).

Population Information and Trends

Population Trends:

70 - 90% decline (NatureServe, 2015)

Species Trends:

>70% decline (NatureServe, 2015)

Number of Populations:

~11 (USFWS, 2019)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

The clubshell was listed as endangered, without critical habitat, in 1993. Historically, the clubshell was once abundant and appears to have been a highly successful species occupying a range of riverine habitats throughout the Ohio River basin and tributaries of western Lake Erie (Stansbery et al. 1982). It has been documented in over 100 streams throughout its range, although it now appears to be limited to 11 populations distributed in 30 streams. Only eight clubshell populations show evidence of recent reproductive success. (USFWS, 2019)

Threats and Stressors

Stressor: Habitat degradation (NatureServe, 2015; USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: This species is threatened by domestic and industrial waste and navigation developments in the upper Ohio and Wabash river watersheds. Stansbery (pers. comm.) believed that various pesticides were at least partially responsible for the overall decrease in the fauna of areas in which Pleurobema clava was present. Proposed coal mining in the Elk River watershed may threaten that population. The species is particularly vulnerable to siltation, which clogs the substrate interstices and suffocates the animal (NatureServe, 2015). A variety of instream activities threaten clubshell populations, including sand and gravel dredging, gravel bar removal, bridge construction, and pipeline construction. Land-based development near streams often results in loss of riparian habitat, increased stormwater runoff, increased sedimentation, and degradation of stream banks (USFWS, 2009).

Stressor: Predation (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Several small animals prey on this species, including muskrats, raccoons, otters, molluscivous fish, and some invertebrates. This could represent a significant threat to small, isolated clubshell populations (USFWS, 2009).

Stressor: Zebra mussels (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Zebra mussels (Dreissena polymorpha) have been documented in headwater lakes and reservoirs of a number of streams supporting clubshell populations. The presence of zebra mussels may also cause increased use of molluscides to treat zebra mussel infestations (USFWS, 2009).

Stressor: Stochastic events (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: The isolated nature of remaining clubshell populations combined with life history traits means that natural recolonization is unlikely in the event of a natural or manmade catastrophic event. The small, isolated populations are particularly vulnerable to extirpation due to losses resulting from events such as floods, droughts, toxicant spills, or other stochastic events (USFWS, 2009).

Recovery

Reclassification Criteria:
Viable populations must be documented in 10 separate drainages. A viable population consists of sufficient numbers of reproducing individuals to maintain a stable or increasing population.

These populations should include as many subpopulations as possible to maintain whatever fraction of the original genetic variability that remains (USFWS, 2009).

Delisting Criteria:
1. Each of the 10 populations in the reclassification criterion must be large enough to survive a single adverse ecological event. Most populations at this time are localized and susceptible to such impacts. Therefore, the extent of most populations must be increased, either naturally or through translocation (USFWS, 2009).

2. The populations and their drainages from the previous criteria must be permanently protected from all foreseeable and controllable threats, both natural and anthropogenic (USFWS, 2009).

Recovery Actions:
- Initiate and participate in ecosystem conservation effort (USFWS, 1994).
- Protect and manage mussel populations and their habitat on a site-specific basis (USFWS, 1994).
- Collect data on both species that are necessary for their recovery (USFWS, 1994).
- As needed, restore habitats and reintroduce the species to suitable areas (USFWS, 1994).
- Enlist public support for the recovery process through an outreach program and incentives (USFWS, 1994).
- The recovery plan for the clubshell is more than 10 years old. A significant amount of information is available regarding threats to the essential recovery streams identified in the plan. A revised plan will assist local and State entities in planning watershed and ecosystem actions to recover habitat for eventual relocation. The recovery criteria also need to be updated to specifically address each of the relevant listing factors (USFWS, 2009).
- Identify and map actual and potential threats at existing sites, and identify activities or practices that may affect the clubshell (USFWS, 2009).
- Assess the effects of stream regulation on the existing populations, and develop recommendations for dam operators to protect and enhance downstream clubshell habitat (USFWS, 2009).
- Determine contaminant sensitivity for each life stage, particularly silt concentrations (USFWS, 2009).
- Implement a quantitative monitoring program at sites within the reproducing populations to assess the reproductive condition of these populations (USFWS, 2009).
- Continue genetic analysis to define the ranges of clubshell (Pleurobema clava) and Tennessee clubshell (Pleurobema oviforme) in the Cumberland and Tennessee Rivers (USFWS, 2009).
- Captive and in situ holding of clubshell may provide additional options for the species' recovery and re-establishment into historic habitat through augmentation or reintroduction of relocated animals or captive propagation. Husbandry methods should be developed, and an assessment of historic habitat completed to identify sites where clubshell augmentation and re-establishment can be achieved (USFWS, 2009).
- Recovery Priority Number of 5 indicates that the clubshell is taxonomically categorized as a species, has a high degree of threat, and has low recovery potential.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Recommendation: Revise recovery plan. The clubshell Recovery Plan is more than 20 years old. A significant amount of information is available regarding threats to the essential recovery streams identified in the plan. A revised plan will assist local and state entities in planning watershed and ecosystem actions to recover habitat for eventual relocation. The recovery criteria also need to be updated to specifically address each of the relevant listing factors. Recommendations for specific priority recovery actions: The following recovery actions should be made a priority: Priority 1 Recovery Actions: 1) Continue to survey for clubshell to determine abundance, distribution, and recruitment. 2) Identify and map both actual and potential threats at existing sites, and identify activities or practices that may affect the clubshell. 3) Continue to monitor reintroduction and augmentation sites to determine if natural reproduction is occurring. 4) Determine contaminant sensitivity for each life stage, particularly chloride, nutrients, and trace metal concentrations and develop recommendations for EPA and state water quality criteria to protect and enhance clubshell habitat. Priority 2 Recovery Actions: 1) Assess the effects of streamflow manipulation on the existing populations, and develop recommendations for dam operators, water withdrawal, and state water quality criteria to protect and enhance clubshell habitat. 2) Implement a quantitative monitoring program at sites within the reproducing populations to assess the reproductive success of these populations. 3) Continue captive and in situ holding programs of the clubshell, which have provided additional options for the species' recovery and re-establishment into historical habitat through augmentation or reintroduction of relocated animals or captive propagation. 4) Publish a FWS clubshell propagation plan with feeding regime and captive care protocols. Priority 3 Recovery Actions: 1) Continue genetic analysis to define the ranges of the clubshell (Pleurobema clava) and the Tennessee clubshell (Pleurobema oviforme) in the Cumberland and Tennessee Rivers . 2) Conduct genetic analyses of mussels used for relocation/augmentation, and compare to original population at augmentation sites. 3) 3) Develop database of stocking programs, and broodstock source; include genetic information on broodstock and progeny. (USFWS, 2019)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed June 2016

U.S. Fish and Wildlife Service. 1994. Clubshell (Pleurobema clava) and Northern Riffleshell (Epioblasma torulosa rangiana) Recovery Plan. Hadley, Massachusetts. 68 pp.

USFWS 2009. Clubshell (Pleurobema clava) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field office. State College, Pennsylvania

USFWS 2009. Clubshell (Pleurobema clava) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field office. State College, Pennsylvania. USFWS. 2019. Clubshell (Pleurobema clava) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field Office 110 Radnor Road, Suite 101 State College, Pennsylvania 16801. 33 pp.

USFWS 2009. Clubshell (Pleurobema clava) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field office. State College, Pennsylvania.

USFWS. 2009. Clubshell (Pleurobema clava) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field office. State College, Pennsylvania.

USFWS. 2019. Clubshell (Pleurobema clava) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pennsylvania Field Office 110 Radnor Road, Suite 101 State College, Pennsylvania 16801. 33 pp.

SPECIES ACCOUNT: *Pleurobema collina* (James spinymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered; 07/22/1988; Northeast Region (R5) (USFWS, 2015)

Physical Description

One of three freshwater mussels where prominent spines can be found on juvenile shells. Adults have a dark brown shell and the spines are typically absent or reduced (NatureServe, 2015).

Taxonomy

Clarke and Neves (1984) suggested placing the species in the genus Canthyria due to the presence of spines on the shell and some characters of soft anatomy (USFWS, 1990). Perkins et al. (2017), as described above in section 2.3.1.3, concluded that JSM and TRS formed their own clade based on genetic analysis and described a new genus, Parvaspina, in the tribe Pleurobemini. Williams et al. (2017) provided a revised list of freshwater mussels in the United States and Canada and updated the taxonomy and nomenclature of many mussels, including the change of genus name for JSM from Pluerobema to Parvaspina. Therefore, the commonly accepted scientific name for JSM is Parvaspina collina. On February 17, 2022, the Service formalized the taxonomic change in the Federal Register (87 FR 8960-8967) (USFWS, 2022).

Historical Range

Based on collection records, this species was endemic to the upper James River drainage (mainstem and tributaries including the Rivanna and North) above Richmond Virginia (NatureServe, 2015).

Current Range

Recent records of this species from the Dan River (a Roanoke River tributary) in Stokes Co., North Carolina (Savidge and Wood, 2001) corroborate historic stream capture between the headwaters of the Roanoke and James River systems in the mountains of Virginia (Johnson, 2006). It is currently restricted to a few small headwater tributaries in Virginia (Lipford, 1989) and West Virginia and in a few rivers (Tar River and Dan River) in North Carolina (Boss and Clench, 1967; Hove and Neves, 1991; Bogan, 2002; Savidge and Wood, 2001) (NatureServe, 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Seven fish hosts, all in the family Cyprinidae (minnows), have been identified (USFWS, 1990).

Adult: Like other freshwater mussels, it feeds by filtering food particles from the water (USFWS, 1988).

Reproduction Narrative

Adult: This species is a short-term brooder that releases glochidia in summer (late May through early August). The following fish hosts are reported in Neves (1991) and Hove and Neves (1991; 1994): the rosyside dace (Clinostomus funduloides), bluehead chub (Nocomis leptocephalus), mountain redbelly dace (Phoxinus oreas), blacknose dace (Rhynichthys atratulus), central stoneroller (Campostoma anomalum), rosefin shiner (Lythrus ardens), satinfin shiner (Cyprinella analostana), and possibly the swallowtail shiner (Notropis procne) (NatureServe, 2015). Male mussels release sperm into the water column which are taken in by females during siphoning (USFWS, 1990).

Geographic or Habitat Restraints or Barriers

Adult: Impoundments, lack of lotic connections, water depth > 10 m (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Habitat Narrative

Adult: This species is found in waters with slow to moderate current and relatively hard water on sand and mixed sand and gravel substrates (Boss and Clench, 1967). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). This species lives in stream sites that vary in width from 10-75 feet and depth of 1/2 to 3 feet. It requires a slow to moderate water current with clean sand and cobble bottom sediments. The spinymussel is limited to areas of unpolluted water (USFWS, 1990).

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 1990)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Restricted distribution hinders dispersal capabilities (NatureServe, 2015). Mussels are sedentary and unable to move long distances (USFWS, 1990).

Population Information and Trends

Population Trends:

>70% decline (NatureServe, 2015)

Species Trends:

>70% decline (NatureServe, 2015)

Number of Populations:

4 (USFWS, 2022)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

The distribution of this species is defined as occurring in five 'sub-drainages' (Hove and Neves, 1991; 1994), mostly in Virginia. The population size is unknown. Although it is likely that the decline of this species began with municipal growth and industrialization of cities and towns in the James River watershed, much of the decline has occurred in the last 20 years. It remained widespread through the mid-1960s but now appears to be extirpated from approximately 90% of its historic range (USFWS, 1990). This species has experienced a long term and short term decline of >70% (NatureServe, 2015). Four James River mussel populations (USFWS, 2022).

Threats and Stressors

Stressor: Siltation (USFWS, 1990)
Exposure:
Response:
Consequence:
Narrative: Siltation, generated by agricultural and forestry activities and road construction, is a significant factor contributing to water quality problems and the consequent decline of the James spinymussel. Natural sedimentation resulting from seasonal storm events probably does not significantly affect mussels, but human activities often create excessively heavy silt loads that can have severe effects on mussels and other aquatic organisms (USFWS 1987). Suspended sediment can clog the gills of filter feeding mussels and eventually suffocate them, so mussels often respond by closing their valves (Ellis 1936). Kitchel et al. (1981) reported reduced siphoning activity, and consequently reduced feeding, by mussels placed in aquaria with suspended coal fines (USFWS, 1990).

Stressor: Asian clam (USFWS, 1990)
Exposure:
Response:
Consequence:
Narrative: The invasion of the Asian clam may be one of the most significant threats to the James spinymussel (Clarke and Neves 1984). Once established in a river, Corbicula fluminea populations achieve high densities and expand rapidly. Malacologists are now concerned about the possibility of a competitive interaction between Asian clams and native bivalves. It is not unreasonable to conclude that C. fluminea has the potential to deplete the food supply of unionids (USFWS, 1990).

Stressor: Impoundments (USFWS, 1990)
Exposure:
Response:
Consequence:

Narrative: Impoundments on rivers in the Southeast have been responsible for the decline of many mussel populations. Closure of dams changes habitat from lotic to lentic conditions. Fish communities change, and host fish species may be eliminated. Mussel communities change, as species requiring clean gravel and sand substrate are replaced by silt-tolerant species (Bates 1962) (USFWS, 1990).

Stressor: Pollutants (USFWS, 1990)
Exposure:
Response:
Consequence:
Narrative: Many rivers have been severely degraded by pollution from municipal, industrial, and agricultural sources. At various locations in the Southeast, freshwater mussel populations have been reduced and, in some cases, completely extirpated from lakes and streams by pollutants including effluent from chlor-alkali plants, fly ash and sulfuric acid spills (Cairns et al. 1971, Raleigh et a!. 1978), acid mine drainage (Neel and Allen 1964) and organic wastes (Schmidt 1982). Salanki and Varanka (1978) found that insecticides have significant effects on mussels. The disappearance of P. collina from the North River in Rockbridge County, Virginia may well have been brought about by industrial and sewage pollution (Clarke and Neves 1984). Within the present range of the species, several sewage treatment plants pose a potential threat to the spinymussel (USFWS, 1990).

Recovery

Reclassification Criteria:
1. Populations in the Craig Creek drainage and 80% of all other known populations are stable or expanding (focusing on distribution of populations within four rivers or creeks) (USFWS, 1990).

2. All known populations and their habitat are protected from foreseeable threats (USFWS, 1990).

Recovery Priority Number: 8

Delisting Criteria:
1. In addition to the reclassification criteria, populations are re-established or new populations are protected in two additional rivers or three segments of the James River drainage (USFWS, 1990).

2. Habitat protection strategies have succeeded in enhancing 75% of all sites with viable populations (USFWS, 1990).

Recovery Actions:
- Identification of essential habitat (USFWS, 1990).
- Investigation of specific threats such as siltation, pesticide contamination, municipal and industrial effluents, and interactions with the Asian clam (USFWS, 1990).
- Assessment of projects posing potentially negative effects on the species and its habitat, and monitoring of threats (USFWS, 1990).
- Methods to control Asian clams will be implemented as warranted (USFWS, 1990).

- Protection strategies for essential spinymussel habitat will be determined and implemented (USFWS, 1990).
- Studies of the life history and ecological requirements of this species will be conducted in order to determine the feasibility and techniques of re-introducing the species into other areas within its historic range (USFWS, 1990).
- Populations will be re-established as warranted (USFWS, 1990).
- Existing and introduced populations will be monitored on an ongoing basis (USFWS, 1990).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Clarify recovery criteria 1C and 2E to support objective evaluation and achievability and 2D to reflect current information. Criterion 1C is too general and merits clarification because as written, it is quite possibly not achievable to protect all known populations of the species from present and foreseeable anthropogenic and natural threats that may interfere with their survival. Criterion 2E is too specific and is based on demonstrating success based on habitat protection strategies; this criterion should be clarified to include other recovery tools, such as propagation, augmentation, stream restoration, predator trapping, and modification or removal of dams. Criterion 2D should be clarified to include the Roanoke River basin. Recommendations for specific recovery actions and priority number (1-3, based on priority number definitions in the JSM recovery plan [Service 1990]): Recommendations for specific research and data needs 1. Continue long-term, systematic monitoring of JSM populations to improve measurement and understanding of demographic vital rates (e.g., population density and size, recruitment rate, survival rate, fecundity, maturity schedule, age structure, sex ratio), population trends, and changes in populations in response to threats and management actions [Priority 1]. 2. Conduct a population viability analysis to define what is a viable population and to inform management decisions [Priority 1]. 3. Continue genetic analyses of JSM populations to assess genetic diversity and to support development of propagation plans and a genetic management plan [Priority 2]. 4. Continue to assess and survey occurrence streams for JSM, in particular sites that have not been surveyed in more than 15 years, and identify opportunities for JSM recovery [Priority 2]. 5. Continue to conduct research and monitoring to determine the effects of water quality and other stressors/threats, including effects of hydropower peaking operations and Asian clam, on JSM population dynamics [Priority 2]. Recommendations for conservation actions: 1. Protect and maintain the dams on lower order streams, including Little Oregon Creek, Dicks Creek, and Johns Creek, that appear to be providing beneficial effects to JSM and its habitat [Priority 1]. 2. With the state natural resource agencies, identify opportunities for population augmentation to extant waterbodies and reintroduction to historical waterbodies and finalize a captive propagation plan and site-specific augmentation/reintroduction plans for the JSM [Priority 2]. 3. With State and Federal agencies and partners, work to reduce the impacts of dams restricting connectivity and affecting the hydrologic flow regime downstream of the dam, including FERC-licensed hydroelectric dams. Actions may include removing all or part of the dam, revising flow requirements during the FERC relicensing process, and reopening FERC licenses with exemptions (e.g., non-expiring) on waterbodies where JSM was discovered after the exemption was issued [Priority 2]. 4. With the partners, actively promote water quality improvement, stream riparian buffer preservation and establishment, and stream preservation and restoration (if appropriate) projects in the James (i.e., Rivanna subbasin, Little Oregon Creek, Mill Creek, Johns Creek, Craig Creek, Rock Island Creek) and Roanoke River (i.e., Dan River, Mayo River, and South Fork Mayo River) basins. Focus on stream and riparian restoration projects that improve agricultural practices in areas that are somewhat degraded and can be improved, including but limited to: Little Oregon Creek, Mill Creek, South Fork Potts Creek, Pedlar River, Tye River, Johns Creek, Dan River, and South Fork Mayo River [Priority 2].

5. Maintain and increase the present populations through watershed-level conservation approaches that address sediment, nutrient, and contaminant loading and stormwater flows. Work with partners to preserve and improve ecological processes that provide the water quality and quantity and habitat required for the JSM and participate in watersheds planning with Virginia, North Carolina, and West Virginia [Priority 3] (USFWS, 2022).

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

U.S. Fish and Wildlife Service. 1990. James Spinymussel (Pleurobema collina) Recovery Plan. Newton Corner, Massachusetts. 38 pp.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed June 2016. USFWS. 2022. James Spinymussel (Parvaspina collina) 5-Year Review: Summary and Evaluation. Virginia Field Office. Gloucester, Virginia. 102 pages.

USFWS 1988. Endangered and Threatened Wildlife and Plants

Determination of Endangered Status for the James Spinymussel. 53 Federal Register 141. July 22, 1988. Pages 27689 - 27693.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.” USFWS. 2022. James Spinymussel (Parvaspina collina) 5-Year Review: Summary and Evaluation. Virginia Field Office. Gloucester, Virginia. 102 pages.

USFWS. 2022. James Spinymussel (Parvaspina collina) 5-Year Review: Summary and Evaluation. Virginia Field Office. Gloucester, Virginia. 102 pages.

SPECIES ACCOUNT: *Pleurobema curtum* (Black clubshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 4/7/1987; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A freshwater mussel or bivalve mollusk that reaches an adult size of about 50 millimeters (mm) or 2 inches (in) in length. The shell varies from green in young shells to a dark greenish-black in older shells. (NatureServe, 2015)

Taxonomy

The genus Pleurobema is a confusing lot even among malacologists who are familiar with the genus group. The Mobile Basin Pleurobema are especially confusing given the similarities between nominal species. (NatureServe, 2015)

Historical Range

Historically, this species was known from the Tombigbee River near Pickensville, Alabama and the East Fork Tombigbee River downstream of its confluence with Bull Mountain Creek. Mirarchi et al. (2004) cite former distribution in Alabama as the mainstem of the Tombigbee River. A short section of the upper Tombigbee River in Mississippi (Hartfield and Jones, 1989) contained a small persistent population until the mid-1980s but is now extirpated (Mirarchi et al., 2004). A single record from the Big Black River, Mississippi (Hartfield and Rummel, 1985), is believed to be an error (USFWS, 1989). It is considered historical in Mississippi in the Tombigbee River drainage (Jones et al., 2005) with the unlikely potential that a living population might be found. (NatureServe, 2015)

Current Range

The current range of the species appears to be limited to the East Fork Tombigbee River in Mississippi (USFWS, 1989; 2000; Paul Hartfield, pers. comm. October, 1992) although no live specimens have been found there despite intensive surveys in 1990, 91, 92, 93, 97, 99, 2001 with the last dead shells collected in 1989 and 1990 (Paul Hartfield, pers. comm., September 2003). It is extirpated from Alabama following construction of Tennessee-Tombigbee Waterway (Mirarchi et al., 2004). (NatureServe, 2015)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: No information available. Pleurobema taitianum is a filter feeder (USFWS, 1989) (NatureServe, 2015).

Reproduction Narrative

Adult: The glochidial host is not known. It is a short-term brooder, gravid in spring and summer (P. Johnson, pers. comm., 2010) (NatureServe, 2015). The reproductive cycle of freshwater mussels is similar among all species. During the spawning period, males discharge sperm into the water column, and the sperm are taken in by females during siphoning. Eggs are fertilized in the suprabranchial cavity or gills, which also serve as marsupia for larval development to mature glochidia. Upon release into the water column, mature glochidia attach to the gills and fins of appropriate host fishes. Freshwater mussels are long lived - up to 50 years or more. They usually reach sexual maturity in 2-4 years (USFWS, 1989).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred form NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species is found in riffles and shoals on sandy gravel to gravel-cobble substrates and with moderate to fast currents in lotic habitat (USFWS, 2000; Mirarchi et al., 2004). It requires clean water and the environmental specificity is narrow. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Long-term decline of >90% (NatureServe, 2015). Species has not been seen since 1997. Continue searching for another 5-years before recommending that species is likely extirpated (USFWS, 2015).

Number of Populations:

1 (USFWS, 2009)

Adaptability:

Very low (inferred from NatureServe, 2015)

Population Narrative:

Low population levels cause increased difficulty in completing successful reproduction. When individuals become scattered, the opportunity for the female to become gravid is greatly diminished. With low population levels, any impact is a major threat (USFWS, 1989). Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). The species is nearly extinct and is considered extirpated in Alabama by construction of the Tennessee-Tombigbee Waterway (Mirarchi et al., 2004). This species has experienced a long-term decline of >90%. The range extent is less than 40 square miles (NatureServe, 2015). This species has not been observed since 1997 and only a single population of black clubshell (East Fork Tombigbee River, Monroe/Itawamba County, Mississippi) has been documented since the species was listed. No information on genetics is available (USFWS, 2009). Live black clubshells have not been observed since the construction of the Tennessee-Tombigbee Waterway, and fresh dead shells of the species were last collected in 1997 from a single shoal on the East Fork Tombigbee River, Itawamba County, MS. The East Fork Tombigbee River was last searched for the species in 2011 (Hamstead et al., 2020). No new surveys have been completed since the 2015 5-year review, and there is no new information regarding survival of the black clubshell at this location; however, mussel habitats within the East Fork Tombigbee River continue to support a diverse although altered mussel community (Service 2015; Hamstead et al., 2020). (USFWS, 2021)

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS 1989)
Exposure:
Response:

Consequence:
Narrative: The primary cause of population decline for Black clubshell is habitat modification for navigation. Construction of the Tennessee-Tombigbee Waterway adversely impacted these mussels by physical destruction during dredging, increasing sedimentation, reducing water flow, and suffocating juveniles with sediment. The upper Tombigbee River was converted from a free-flowing riverine system into a series of impoundments. The remaining habitat in the mainstem Tombigbee River occurs in several bendways resulting from channel cuts. These bendways have experienced reduced flows and increased sediment accumulation (USFWS, 1989).

Stressor: Water diversion (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: Water diversion continues to threaten Flat pigtoe, especially in the East Fork Tombigbee River. The Tennessee-Tombigbee Waterway canal section significantly altered water flows from eastern tributaries of the East Fork. Minimum flow structures were built into the Waterway to maintain flows in tributaries from which higher flushing flood flows were diverted. At least one municipality proposes to use the East Fork as a water supply and remove up to 136 million liters or 30 million gallons (gal) per day. Unless the Waterway canal structures continually release the planned amounts of water, the withdrawal of such a large quantity of municipal water would very likely jeopardize the mussels in the East Fork. Should any other water withdrawal occur, there must be corresponding water releases from the Waterway to avoid adverse impacts to mussels. The accumulation of sediment in the East Fork downstream of Mill Creek is likely due to the diversion of flushing flows by the Waterway canal cut from Bull Mountain Creek through the Lock B spillway some 6.4 km (4 mi) downstream (USFWS, 1989).

Stressor: Runoff of fertilizers and pesticides (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: Runoff of fertilizers and pesticides into these tributaries may adversely impact freshwater mussels. Such runoff can exceed the assimilation ability of the stream and result in algal blooms and excesses of other aquatic vegetation. This condition can produce eutrophication and result in the death of mussels. Pesticides washed into the stream are ingested by filter feeders while being transported downstream. Pesticide-laden silt particles eventually settle to and become part of the substratum, increasing the concentration of pesticides in mussel habitats (USFWS, 1989).

Stressor: Small population size (USFWS 1989, 2009)
Exposure:
Response:
Consequence:
Narrative: The low population levels cause increased difficulty for successful reproduction. When individuals are scattered, the opportunity for a female to siphon sperm and fertilize eggs is diminished. This results in fewer gravid females in proximity to the host species. With low population levels, any event that impacts one of these species is of major significance (USFWS, 1989). A small population is known to have persisted on a single shoal in the East Fork Tombigbee River through 1997 (USFWS, 2009).

Recovery

Reclassification Criteria:
The recovery of this species, to a degree that would permit down-listing to threatened, is unlikely due to few numbers and lack of suitable habitat within their historic range (USFWS, 1989).

Recovery Priority Number: 5C.

Delisting Criteria:
Not available

Recovery Actions:
- Protect the known habitat (USFWS, 1989).
- Determine habitat requirements and management needs (USFWS, 1989).
- Implement management needs (USFWS, 1989).
- Survey populations to determine trends (USFWS, 1989).
- Develop measurable recovery criteria (USFWS, 2009).
- Develop and implement plan to quantify and monitor surviving populations and habitats (USFWS, 2009).
- Develop and implement plan to describe and monitor habitat conditions at potential reintroduction sites (USFWS, 2009).
- Continue to work with States to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS, 2009).
- Work with AABC to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2009).
- RECOMMENDATIONS FOR FUTURE ACTIONS: (1) Continue to search for black clubshell, heavy pigtoe, and southern combshell; quantify, and monitor surviving populations and habitats. (2) Complete the draft Strategic Habitat Conservation Plan for the Buttahatchee River. (3) Maintain and enhance conservation partnerships within the Tombigbee drainage and Mobile River Basin. (4) Develop and implement a strategic habitat conservation plan for the East Fork Tombigbee River. (4) Continue to describe and monitor habitat conditions at potential reintroduction sites. (5) Continue to work with States to refine and implement the Mobile River Basin Mollusk Propagation Plan. (6) Continue to work with AABC to propagate and reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2015).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Conduct comprehensive survey for black clubshell in the East Fork Tombigbee River prior to determining extinction. 2. Continue to monitor the Buttahatchee River southern combshell population. 3. Continue to augment and monitor reintroduced southern combshell populations in the Cahaba River and Bull Mountain Creek. 4. Maintain and enhance conservation partnerships within the Tombigbee drainage and Mobile River Basin. Develop and implement a strategic habitat conservation plan for the East Fork Tombigbee River. 5. Continue to support AABC mission to propagate and reintroduce hatchery reared imperiled mollusks into restored habitats, as appropriate. (USFWS, 2021)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

U.S. Fish and Wildlife Service, 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia.

USFWS 2009. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Jackson Ecological Services Field Office Jackson, Mississippi. U.S. Fish and Wildlife Service. 2015. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jackson Ecological Services Field Office Jackson, Mississippi. 16 pp. USFWS. 2021. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) 5-Year Review: Summary and Evaluation – 2021. U.S. Fish and Wildlife Service South Atlantic-Gulf Region and Mississippi Basin Regions Jackson Ecological Services Field Office Jackson, Mississippi. 13 pp.

U.S. Fish and Wildlife Service. 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 18 pp.

USFWS. 2009. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum), Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli), Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum), Southern Combshell (Penitent Mussel) (Epioblasma penita), Stirrupshell (Quadrula stapes)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jackson Ecological Services Field Office Jackson, Mississippi. 24 pp.

U.S. Fish and Wildlife Service, 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 18 pp.

USFWS 2009. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes) 5-Year

Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Jackson Ecological Services Field Office, Jackson, Mississippi.

U.S. Fish and Wildlife Service. 2015. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jackson Ecological Services Field Office Jackson, Mississippi. 16 pp.

USFWS. 2021. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) 5-Year Review: Summary and Evaluation – 2021. U.S. Fish and Wildlife Service South Atlantic-Gulf Region and Mississippi Basin Regions Jackson Ecological Services Field Office Jackson, Mississippi. 13 pp.

SPECIES ACCOUNT: *Pleurobema decisum* (Southern clubshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 3/17/1993; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A freshwater mussel or bivalve mollusk which attains an average adult size of 70 mm (2.8 in.) in length. The outer shell is yellow to yellowish-brown with occasional green rays or spots on the umbo of young specimens (U. S. Fish and Wildlife Service, 1993).This species has a thick shell, and heavy hinge plate and teeth. Shell outline is roughly rectangular, produced posteriorly with the umbos terminal with the anterior margin, or nearly so. The posterior ridge is moderately inflated and ends abruptly with little development of the posterior slope at the dorsum of the shell. Periostracum is yellow to yellow-brown with occasional green rays or spots on the umbo in young specimens (FWS, 2003). LENGTH:7 (NatureServe, 2015)

Taxonomy

Genetic analysis is needed to compare this species with Pleurobema chattanoogaensis and forms of the species (i.e., Pleurobema crebrivittatus and Pleurobema pallidovulvus) that are recognized by the U.S. Fish and Wildlife Service as synonyms. (NatureServe, 2015)

Historical Range

Formerly widespread throughout the Mobile River basin, Pleurobema decisum was known historically from the Alabama River and Bogue Chitto Creek; Tombigbee River and tributaries (Buttahatchie, East Fork Tombigbee, and Sipsey Rivers and Bull Mountain, Luxapalila, and Lubbub Creeks); Black Warrior River; Cahaba and Little Cahaba Rivers; two Tallapoosa tributaries, Uphapee and Chewacla Creeks; and the Coosa River and tributaries (Oostanaula, Conasauga, Etowah, Chatooga, and Coosawattee Rivers and Kelly, Talladega and Shoal Creeks) in Mississippi, Alabama, Georgia, and Tennessee (USFWS, 2004). Currently, the species is known from Bogue Chitto Creek in Alabama River drainage; Buttahatchie, East Fork Tombigbee and Sipsey Rivers in the Tombigbee River drainage; and Chewacla Creek in the Tallapoosa River drainage (U. S. Fish and Wildlife Service 1993; McGregor et. al. 1999). It has recently been found in the Conasauga River, Whitfield and Murray Counties, Georgia in the upper Coosa River drainage (Mark Hughes, pers. comm. 2/10/1997). In the Coosa River basin in Georgia, it is known historically from the Coosa, Etowah, Oostanaula, Conasauga, and Coosawattee River drainages but has not been collected there recently (Williams and Hughes, 1998) except in the Conasauga (Johnson et al., 2005). (NatureServe, 2015)

Current Range

Mirarchi et al. (2004) and Williams et al. (2008) list distribution as endemic to Mobile Basin in Alabama, Georgia, and Mississippi including Alabama, Black Warrior, Cahaba, Coosa, Tallapoosa, and Tombigbee River systems with large populations remaining only in widely scattered localities in Tombigbee River system (may be extirpated from Black Warrior and Cahaba). Jones et al. (2005) list the Tombigbee River drainage in Mississippi. McGregor et al. (2000) failed to find this species in the Cahaba River, Alabama. (NatureServe, 2015)

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description
On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the southern clubshell, under the Endangered Species Act of 1973, as amended (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat is designated for the southern clubshell (Pleurobema decisum) in Units 1, 2, 3, 4, 5, 6, 7, 8, 9, 13, 14, 15, 17, 18, 19, 21, 24, 25, 26; in AL, GA, MS, and TN.

Unit 1. East Fork Tombigbee River, Monroe, Itawamba Counties, Mississippi. Unit 1 encompasses 26 km (16 mi) of the East Fork Tombigbee River channel in Mississippi extending from Mississippi Highway 278, Monroe County, upstream to the confluence of Mill Creek, Itawamba County, Mississippi. This reach of the East Fork Tombigbee River continues to support the southern clubshell and orange-nacre mucket (Hartfield and Jones, 1989; Miller and Hartfield, 1988; Mississippi Museum of Natural Science (MMNS) mussel collections, 1984–2001). This unit is within the historic range of the Alabama moccasinshell and ovate clubshell.

Unit 2. Bull Mountain Creek, Itawamba County, Mississippi. Unit 2 encompasses 34 km (21 mi) of the Bull Mountain Creek stream channel in Mississippi extending from Mississippi Highway 25, upstream to U.S. Highway 78, Itawamba County, Mississippi. Bull Mountain Creek supports the southern clubshell and Alabama moccasinshell (Jones and Majure, 1999). This unit is within the historic range of the orange-nacre mucket (records are from the early 1980’s (MMNS mussel collections)) and the ovate clubshell.

Unit 3. Buttahatchee River and tributary, Lowndes/Monroe County, Mississippi; Lamar County, Alabama. Unit 3 encompasses 110 km (68 mi) of river and stream channel in Mississippi and Alabama, including 87 km (54 mi) of the Buttahatchee River, extending from its confluence with the impounded waters of Columbus Lake (Tombigbee River), Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and 23 km (14 mi) of Sipsey Creek, extending from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi. The Buttahatchee River continues to support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 2001; Hartfield and Jones, 1989; Jones, 1991; McGregor, 2000). The current distribution of the Alabama moccasinshell also extends into its tributary Sipsey Creek (McGregor, 2000).

Unit 4. Luxapalila Creek and tributary, Lowndes County, Mississippi; Lamar County, Alabama. Unit 4 encompasses 29 km (18 mi) of stream channel, including 15 km (9 mi) of Luxapalila Creek, extending from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and 15 km (9 mi) of Yellow Creek extending from its confluence with Luxapalila Creek, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama. Luxapalila and Yellow Creeks support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Hartfield and Bowker, 1992; McGregor, 2000; Miller, 2000; Yokley 2001).

Unit 5. Coalfire Creek, Pickens County, Alabama. Unit 5 encompasses 32 km (20 mi) of the Coalfire Creek stream channel extending from its confluence with the impounded waters of

Aliceville Lake (Tombigbee River), upstream to U.S. Highway 82, Pickens County, Alabama. Coalfire Creek supports the orange-nacre mucket and ovate clubshell (P. Hartfield, Service field records 1991; McGregor, 2000). The creek is in the historic range of the southern clubshell and Alabama moccasinshell.

Unit 6. Lubbub Creek, Pickens County, Alabama. Unit 6 encompasses 31 km (19 mi) of the Lubbub Creek stream channel extending from its confluence with the impounded waters of Gainesville Lake (Tombigbee River), upstream to the confluence of Little Lubbub Creek, Pickens County, Alabama. This stream supports the southern clubshell, orangenacre mucket, and Alabama moccasinshell (P. Hartfield, Service field records, 1991; McGregor, 2000; Pierson, 1991a). It is in the historic range of the ovate clubshell.

Unit 7. Sipsey River, Greene/Pickens, Tuscaloosa Counties, Alabama. Unit 7 encompasses 90 km (56 mi) of the Sipsey River channel from the confluence with the impounded waters of Gainesville Lake (Tombigbee River), Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama. This small river supports and provides some of the best remaining habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 1997; McCullagh et al., 2002; McGregor, 2000; MMNS Mussel Collection; Pierson, 1991 a, b).

Unit 8. Trussels Creek, Greene County, Alabama. Unit 8 encompasses 21 km (13 mi) of creek channel extending from its confluence with the impounded waters of Demopolis Lake (Tombigbee River), upstream to Alabama Highway 14, Greene County, Alabama. The orangenacre mucket continues to survive in Trussels Creek, and it is in the historic range of the ovate clubshell, Alabama moccasinshell, and southern clubshell (P. Hartfield field records, 1993; McGregor, 2000).

Unit 9. Sucarnoochee River, Sumter County, Alabama. Unit 9 encompasses 90 km (56 mi) of the Sucarnoochee River channel in Alabama, extending from its confluence with the Tombigbee River, upstream to the Mississippi/Alabama State Line, Sumter County, Alabama. The ovate clubshell continues to survive in the Sucarnoochee River (McGregor et al., 1996). The river is within the historic range of the southern clubshell, orangenacre mucket, and Alabama moccasinshell.

Unit 14. Alabama River, Autauga, Lowndes, Dallas Counties, Alabama. Unit 14 encompasses 73 km (45 mi) of the Alabama River channel, extending from the confluence of the Cahaba River, Dallas County, upstream to the confluence of Big Swamp Creek, Lowndes County, Alabama. The southern clubshell is known to occur within this reach (Hartfield and Garner, 1998). This area may become suitable for reintroduction of the orange-nacre mucket.

Unit 15. Bogue Chitto Creek, Dallas County, Alabama. Unit 15 encompasses 52 km (32 mi) of the Bogue Chitto Creek channel in Alabama, extending from its confluence with the Alabama River, Dallas County, upstream to U.S. Highway 80, Dallas County, Alabama. This stream continues to support the southern clubshell and orange-nacre mucket (McGregor et al., 1996; P. Hartfield field notes, 1984; Pierson, 1991a). The habitat offers potential for the Alabama moccasinshell.

Unit 17. Uphapee/Choctafaula/ Chewacla Creeks, Macon, Lee Counties, Alabama. Unit 17 encompasses 74 km (46 mi) of stream channel in Alabama, including: Uphapee Creek, 18 km (11 mi) of river channel extending from Alabama Highway 199, upstream to confluence of Opintlocco and Chewacla Creeks, Macon County, Alabama; Choctafaula Creek, 11 km (7 mi), from confluence with Uphapee Creek, upstream to Macon County Road 54, Macon County, Alabama; Chewacla Creek, 29 km (18 mi), from confluence with Opintlocco Creek, Macon County, Alabama, upstream to Lee County Road 159, Lee County, Alabama; Opintlocco Creek, 16 km (10 mi), from confluence with Chewacla Creek, upstream to Macon County Road 79, Macon County, Alabama. This stream network supports small and localized populations of the fine-lined pocketbook, ovate clubshell, and southern clubshell (M. Gangloff, Auburn University, in litt., 2001; Gangloff, 2002; McGregor, 1993; Pierson, 1991a).

Unit 18. Coosa River (Old River Channel) and tributary, Cherokee, Calhoun, Cleburne Counties, Alabama. Unit 18 encompasses 78 km (48 mi) of river channel in Alabama, including: Coosa River, 18 km (11 mi) extending from the powerline crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Coosa River, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi) from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama. The short reach of the Coosa River continues to support a fairly robust population of the southern clubshell, and a few individuals of the fine-lined pocketbook (Herod et al., 2001). The fine-lined pocketbook and southern clubshell have also been recently collected from Terrapin Creek (Feminella and Gangloff, 2000). This area is within the range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 19. Hatchet Creek, Coosa, Clay Counties, Alabama. Unit 19 encompasses 66 km (41 mi) of the Hatchet Creek channel in Alabama, extending from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama. The fine-lined pocketbook occurs within this reach (Feminella and Gangloff, 2000; Pierson, 1992b). Hatchet Creek is within the historic range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, southern clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 24. Big Canoe Creek, St. Clair County, Alabama. Unit 24 encompasses 29 km (18 mi) of the Big Canoe Creek channel, extending from its confluence with Little Canoe Creek at the St. Clair/ Etowah County line, St. Clair County, upstream to the confluence of Fall Branch, St. Clair County, Alabama. The southern clubshell, southern pigtoe, and triangular kidneyshell are surviving in low numbers in Big Canoe Creek (Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream is also historic habitat for the fine-lined pocketbook, ovate clubshell, Coosa moccasinshell, upland combshell, and southern acornshell.

Unit 25. Oostanaula River/Coosawattee River/Conasauga River/Holly Creek, Floyd, Gordon, Whitfield, Murray Counties, Georgia; Bradley, Polk Counties, Tennessee. Unit 25 encompasses 206 km (128 mi) of river and stream channel in Georgia and Tennessee, including: Oostanaula River, 77 km (48 mi) extending from its confluence with the Etowah River, Floyd County, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; Coosawattee River, 15 km (9 mi), from confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; Conasauga River, 98 km (61 mi), from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and

Polk Counties, Tennessee, to the Murray County Road 2, Murray County, Georgia; Holly Creek, 16 km (10 mi), from confluence with Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia. This extensive riverine reach continues to support small and localized populations of fine-lined pocketbook, southern pigtoe, triangular kidneyshell, Alabama moccasinshell, and Coosa moccasinshell. The triangular kidneyshell survives throughout this unit, while the fine-lined pocketbook, southern pigtoe, and Coosa moccasinshell appear to be currently restricted to the Conasauga River and Holly Creek and the southern clubshell appears restricted to a small 15 km (9 mi) reach of the Conasauga River (Evans, 2001; Johnson and Evans, 2000; Pierson in litt., 1993; Williams and Hughes, 1998). The Alabama moccasinshell is currently known to survive only in the Holly Creek portion of this Unit (Evans, 2001; Johnson and Evans, 2000). The Oostanaula/ Coosawattee/Conasauga Unit also contains historic habitat for the southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the southern clubshell (Pleurobema decisum) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: Mussels filter water for food and oxygen (USFWS, 2004).

Reproduction Narrative

Adult: Gravid females with mature glochidia have been collected in June and July. Glochidia are released in well formed conglutinates orange or white in coloration. Fish hosts include Cyprinella venusta, Cyprinella callista, and Cyprinella trichroistia (Haag and Warren, 2001, FWS, 2003). This species is a short-term brooder gravid from late spring to early summer. Glochidia are released in well formed conglutinates in bursts that drift on the water column and fish hosts include Cyprinella venusta only (Haag and Warren, 2003) (NatureServe, 2015). This species produces an average of 29,433 - 40,887 glochidia per year (Hagg and Station 2003) (USFWS, 2008).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015 and USFWS, 2004)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Usually found in highly oxygenated streams with sand and gravel substrate in shoals of large rivers to small streams; may be found in sand and gravel in the center of the stream or in sand along the margins of the stream (Doug Shelton, pers. obs. 1995; USFWS, 2000). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). Primary constituent elements include: geomorphically stable stream and river channels and banks; a flow regime; water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics necessary (USFWS, 2004)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

> 90% decline (NatureServe, 2015)

Species Trends:

Improving (USFWS, 2008)

Number of Populations:

6 (NatureServe, 2015)

Population Size:

1000 - 2500 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). Except for the Mobile Delta, this species was formerly known from every major stream system in the Mobile River basin, including the Alabama River and tributaries, Alabama; Tomigbee River and tributaries, Mississippi and Alabama; Black Warrior River and tributaries, Alabama; Cahaba and tributaries, Alabama; Uphapee and Chewacla Creeks, Tallapoosa River drainage, Alabama; Coosa River and tributaries, Alabama, Georgia, and Tennessee; but is now limited to about a half dozen viable populations (USFWS, 2000; 2004). This species has experienced a long-term decline of >90%. The range extent is 2,000 - 8,000 square miles, with a population size of 1,000 - 2,500 individuals (NatureServe, 2015). Genetic variation is evident but low between populations (Lydeard et al. 2000). The status has improved regarding numbers of known populations (USFWS, 2008).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species (Neves et al., 1997). The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin (Neves et al., 1997). Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a molluskeating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Stressor: Stochastic events (USFWS, 2008)
Exposure:

Response:
Consequence:
Narrative: All populations of this species are experiencing sediment and water quality problems, and are susceptible to stochastic and chronic events (e.g. spills, drought, and/or landuse runoff) (USFWS, 2008).

Recovery

Reclassification Criteria:
Reclassification does not appear to be a realistic goal for any this species at this time (USFWS, 2000).

Delisting Criteria:
1. At least ten (10) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes. (Factor A) 2. At least one population (as defined in Criteria 1) occupies each of the presently occupied sub-basins: Alabama, Cahaba, Coosa, Tallapoosa, and Tombigbee rivers. (Factors A and E) 3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future. (Factors A-E) (USFWS, 2019)

Recovery Actions:
- Protect habitat integrity and quality (USFWS, 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS, 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Develop measurable recovery criteria (USFWS, 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS, 2008).
- Develop and implement plan to describe and monitor habitat conditions (USFWS, 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS, 2008).
- Work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson, Mississippi

USFWS 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126. July 1, 2004. Pages 40084 - 40171.

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson, Mississippi.

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2019. Southern clubshell Amendment 1 to the U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Pleurobema furvum* (Dark pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 3/17/1993; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A freshwater mussel or bivalve mollusk which attains a maximum adult size of 60 mm (2.4 in.) in length. The outer shell is a dark, reddish brown with numerous closely spaced, dark growth lines. The shell is oval in outline and moderately inflated. The beaks are located in the anterior portion of the shell. The posterior ridge is abruptly rounded and terminates in a broadly rounded, subcentral, posterior point. The periostracum is dark, reddish brown with numerous and closely spaced, dark growth lines. The hinge plate is wide and the teeth are heavy and large, especially in older specimens. The nacre approaches white in the umbos, and is highly iridescent on the posterior margin (FWS, 2003). The length is 6 cm (NatureServe, 2015).

Taxonomy

Williams et al. (2008) treat as a synonym of Pleurobema rubellum based on conchological characters and preliminary genetic analyses. (NatureServe, 2015)

Historical Range

The type locality of Pleurobema furvum is the Black Warrior River, Alabama. Historically, the species was probably restricted to the Black Warrior River system above the fall line (USFWS, 2004). Additional records include the headwaters of the Sipsey Fork and the Locust Fork of the Black Warrior River. Recent records include the North River above Lake Tuscaloosa (USFWS, 1993). (NatureServe, 2015)

Current Range

The current range is limited to the tributaries of the Sipsey Fork, Winston County, and the North River in Tuscaloosa and Fayette Counties and its tributary Clear Creek, Fayette County, all in Alabama (Vittor and Associates, 1993; USFWS, 1993; Mirarchi et al., 2004). (NatureServe, 2015)

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the dark pigtoe, under the Endangered Species Act of 1973, as amended (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat for the dark pigtoe (Pleurobema furvum) is designated in Units 10, 11, 12; in AL.

Unit 10. Sipsey Fork drainage, Winston, Lawrence Counties, Alabama. Unit 10 encompasses 147 km (91 mi) of stream channel in Alabama, including: Sipsey Fork, 31 km (19 mi), from section 11/12 line, T10S R8W, Winston County, upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, 8 km (5 mi), from confluence with Hubbard Creek, upstream to section 2 line, T8S R9W, Lawrence County, Alabama; Brushy Creek, 35 km (22 mi), from the confluence of Glover Creek, Winston County, Alabama, upstream to section 9, T8S R7W, Lawrence County, Alabama; Capsey Creek, 15 km (9 mi), from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County, Alabama; Rush Creek, 10 km (6 mi), from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County, Alabama; Brown Creek, 5 km (3 mi), from confluence with Rush Creek, Winston County, upstream to section 24 line, T8S R7W Lawrence County, Alabama; Beech Creek, 3 km (2 mi), from confluence with Brushy Creek, to confluence of East and West Forks, Winston County, Alabama; Caney Creek and North Fork Caney Creek, 13 km (8 mi), from confluence with Sipsey Fork, upstream to section 14 line, Winston County, Alabama; Borden Creek, 18 km (11 mi), from confluence with Sipsey Fork, Winston County, Alabama, upstream to the confluence of Montgomery Creek, Lawrence County, Alabama; Flannagin Creek, 10 km (6 mi), from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County, Alabama. The upper Sipsey Fork drainage currently supports the most robust and extensive populations of the dark pigtoe, orangenacre mucket, Alabama moccasinshell, and triangular kidneyshell (Haag and Warren, 1997; Haag et al., 1995; Hartfield, 1991; Hartfield and Butler, 1997; Hartfield and Hartfield, 1996; McGregor, 1992; Warren and Haag, 1994). Ovate clubshell have been reported from this drainage (Dodd et al., 1986).

Unit 11. North River and tributary, Tuscaloosa, Fayette Counties, Alabama. Unit 11 encompasses 47 km (29 mi) of river and stream channel in Alabama, including: North River, 42 km (26 mi) extending from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; Clear Creek, 5 km (3 mi), from its confluence with North River, to Bays Lake Dam, Fayette County, Alabama. Small numbers of the dark pigtoe and orange-nacre mucket continue to survive in the North River and Clear Creek (McGregor and Pierson, 1999; Pierson, 1992a; Vittor and Associates, 1993). This area is in the historic range of the Alabama moccasinshell, triangular kidneyshell, and ovate clubshell.

Unit 12. Locust Fork and tributary, Jefferson, Blount Counties, Alabama. Unit 12 encompasses 102 km (63 mi) of river and stream channel in Alabama, including: Locust Fork, 94 km (58 mi) extending from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; Little Warrior River, 8 km (5 mi), from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama. Scattered collections of the orange-nacre mucket and triangular kidneyshell suggest an enduring population of these species in the Locust Fork (P. Johnson pers. comm., 2002; Hartfield, 1991; Shepard et al., 1988). This stream is also in the historic range of the dark pigtoe, Alabama moccasinshell, ovate clubshell, and upland combshell.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the dark pigtoe (Pleurobema furvum) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: Oxygen-bearing water and food are drawn into the incurrent siphon, and waste-carrying water is simultaneously passed out the excurrent siphon. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS, 2000).

Reproduction Narrative

Adult: Freshwater mussel larvae (glochidia) are brooded in the gills of the female and when mature are released into the water where they spend a brief period as obligate parasites on the gills, fins, or other external parts of fish until they drop off to the benthos. In the laboratory, Haag and Warren (1997) identified the following fish as suitable hosts for Pleurobema furvum: Campostoma oligolepis (largescale stoneroller), Cyprinella callista (Alabama shiner), Cyprinella venusta (blacktail shiner), Semotilus atromaculatus (creek chub), and Fundulus olivaceus (blackspotted topminnow). Haag and Warren (1997) also noted that it released its glochidia in conglutinates that may mimic food items of darters and minnows. Females were found gravid with mature glochidia from mid to late June in water temperatures of 25 degrees C (Haag and Warren, 1997). The species is gravid in June and releases glochidia in peach to pink-colored conglutinates (Haag and Warren, 1997) (NatureServe, 2015). While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years (USFWS, 2000).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Unknown (NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species is generally found in highly oxygenated, clear streams with moderate flow. It may be found in sand, but is usually found in a sand and gravel substrate in small rivers and large streams (Doug Shelton, pers. obs., 1996; USFWS, 2000). The environmental specificity of this species in unknown. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls. (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992).Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 70-90% (NatureServe, 2015)

Species Trends:

Unknown (USFWS, 2008)

Number of Populations:

1 - 20 (NatureServe, 2015)

Population Size:

250 - 2500 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). This species has experienced a long-term decline of 70-90%. The range extent of this species is 40 - 100 square miles, with a population size of 250 - 2,500 individuals. There are 1 - 20 occurrences, with 1 - 3 occurrences having good viability/integrity (NatureServe, 2015). The status of the species is unknown, based on a 2007 Recovery Data Call. There is no information on genetic variation within the species. (USFWS, 2008).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species. The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin. Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a mollusk-eating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:

Consequence:
Narrative: All populations of this species are experiencing sediment and water quality problems, and are susceptible to stochastic and chronic events (e.g., spills, drought and/or landuse runoff) (USFWS, 2008).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Recovery

Reclassification Criteria:
Reclassification does not appear to be a realistic goal for this species at this time (USFWS, 2000).

Delisting Criteria:
Delisting does not appear to be a realistic goal for this species at this time (USFWS, 2000).

Recovery Actions:
- Protect habitat integrity and quality (USFWS, 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS, 2000).

- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Develop measurable recovery criteria (USFWS, 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS, 2008).
- Develop and implement plan to describe and monitor habitat conditions where the mussels survive (USFWS, 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS, 2008).
- Work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson, Mississippi.

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Pleurobema georgianum* (Southern pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 3/17/1993; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A medium sized freshwater mussel with a yellow to yellow-brown shell. The shell is elliptical to oval in outline and somewhat compressed. The posterior slope is smoothly rounded. The pseudocardinal teeth are small but well-developed, and the nacre is white. The periostracum is yellow to yellow-brown. Growth lines are numerous and may be dark brown. Small specimens may have green spots at the growth lines along the posterior ridge and near the umbo (FWS, 2003). The length is 6 cm. (NatureServe, 2015)

Taxonomy

It is difficult to differentiate this species from Pleurobema troschelianum and Pleurobema hanleyianum in the field due to similar shell characteristics (Parmalee and Bogan, 1998). (NatureServe, 2015)

Historical Range

It is endemic to the Coosa River drainage of the Mobile Basin in Alabama, Georgia, and Tennessee (Williams et al., 2008). (NatureServe, 2015)

Current Range

It is extant in a few widely scattered tributaries of Coosa River including some streams in Talladega National Forest (Mirarchi et al., 2004; Williams et al., 2008). Recently fresh dead shells (identified as P. troschelianum) were collected in the upper Conasauga River (USFWS, 1999). (NatureServe, 2015)

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the southern pigtoe, under the Endangered Species Act of 1973, as amended (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat for the southern pigtoe (Pleurobema georgianum) is designated in Units 18, 19, 20, 21, 22, 23, 24, 25, 26; in AL, GA, and TN.

Unit 18. Coosa River (Old River Channel) and tributary, Cherokee, Calhoun, Cleburne Counties, Alabama. Unit 18 encompasses 78 km (48 mi) of river channel in Alabama, including: Coosa River, 18 km (11 mi) extending from the powerline crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Coosa River, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi) from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama. The short reach of the Coosa River continues to support a fairly robust population of the southern clubshell, and a few individuals of the fine-lined pocketbook (Herod et al., 2001). The fine-lined pocketbook and southern clubshell have also been recently collected from Terrapin Creek (Feminella and Gangloff, 2000). This area is within the range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 19. Hatchet Creek, Coosa, Clay Counties, Alabama. Unit 19 encompasses 66 km (41 mi) of the Hatchet Creek channel in Alabama, extending from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama. The fine-lined pocketbook occurs within this reach (Feminella and Gangloff, 2000; Pierson, 1992b). Hatchet Creek is within the historic range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, southern clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 20. Shoal Creek, Calhoun, Cleburne Counties, Alabama. Unit 20 encompasses 26 km (16 mi) of stream channel in Alabama, extending from the headwater of Whitesides Mill Lake, Calhoun County, Alabama, upstream to the tailwater of Coleman Lake Dam, Cleburne County, Alabama. The fine-lined pocketbook, southern pigtoe, and triangular kidneyshell survive in Shoal Creek (Haag et al., 1999; Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson, 1992b). Shoal Creek is within historic range of the Coosa moccasinshell.

Unit 21. Kelly Creek and tributary, Shelby, St. Clair Counties, Alabama. Unit 21 encompasses 34 km (21 mi) of stream channel in Alabama, including: Kelly Creek, 26 km (16 mi) extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama; Shoal Creek, 8 km (5 mi), from confluence with Kelly Creek, St. Clair County, Alabama, upstream to St. Clair/ Shelby County Line, St. Clair County, Alabama. Kelly/Shoal Creeks continue to support scattered individuals of the fine-lined pocketbook, and the southern clubshell and triangular kidneyshell survive in Kelly Creek (Pierson pers. comm., 1995; Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream complex is historic habitat for the southern pigtoe, Coosa moccasinshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 22. Cheaha Creek, Talladega, Clay Counties, Alabama. Unit 22 encompasses 27 km (17 mi) of the Cheaha Creek channel, extending from its confluence with Choccolocco Creek, Talladega County, Alabama, upstream to the tailwater of Chinnabee Lake, Clay County, Alabama. The finelined pocketbook and southern pigtoe survive within this reach (Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson, 1992b, 1993). Cheaha Creek is in the historic range of the Coosa moccasinshell and triangular kidneyshell.

Unit 23. Yellowleaf Creek and tributary, Shelby County, Alabama. Unit 23 encompasses 39 km (24 mi) of stream channel, including: Yellowleaf Creek, 32 km (20 mi), extending from Alabama Highway 25, upstream to Shelby County Road 49; Muddy Prong, 7 km (4 mi), extending from confluence with Yellowleaf Creek, upstream to U.S. Highway 280, Shelby County, Alabama. Yellowleaf and Muddy Prong Creeks are currently inhabited by the fine-lined pocketbook (Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson in litt., 2000). Yellowleaf Creek is in the historic range of the Coosa moccasinshell, southern pigtoe, and triangular kidneyshell.

Unit 24. Big Canoe Creek, St. Clair County, Alabama. Unit 24 encompasses 29 km (18 mi) of the Big Canoe Creek channel, extending from its confluence with Little Canoe Creek at the St. Clair/ Etowah County line, St. Clair County, upstream to the confluence of Fall Branch, St. Clair County, Alabama. The southern clubshell, southern pigtoe, and triangular kidneyshell are surviving in low numbers in Big Canoe Creek (Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream is also historic habitat for the fine-lined pocketbook, ovate clubshell, Coosa moccasinshell, upland combshell, and southern acornshell.

Unit 25. Oostanaula River/Coosawattee River/Conasauga River/Holly Creek, Floyd, Gordon, Whitfield, Murray Counties, Georgia; Bradley, Polk Counties, Tennessee. Unit 25 encompasses 206 km (128 mi) of river and stream channel in Georgia and Tennessee, including: Oostanaula River, 77 km (48 mi) extending from its confluence with the Etowah River, Floyd County, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; Coosawattee River, 15 km (9 mi), from confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; Conasauga River, 98 km (61 mi), from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to the Murray County Road 2, Murray County, Georgia; Holly Creek, 16 km (10 mi), from confluence with Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia. This extensive riverine reach continues to support small and localized populations of fine-lined pocketbook, southern pigtoe, triangular kidneyshell, Alabama moccasinshell, and Coosa moccasinshell. The triangular kidneyshell survives throughout this unit, while the fine-lined pocketbook, southern pigtoe, and Coosa moccasinshell appear to be currently restricted to the Conasauga River and Holly Creek and the southern clubshell appears restricted to a small 15 km (9 mi) reach of the Conasauga River (Evans, 2001; Johnson and Evans, 2000; Pierson in litt., 1993; Williams and Hughes, 1998). The Alabama moccasinshell is currently known to survive only in the Holly Creek portion of this Unit (Evans, 2001; Johnson and Evans, 2000). The Oostanaula/ Coosawattee/Conasauga Unit also contains historic habitat for the southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 26. Lower Coosa River, Elmore County, Alabama. Unit 26 encompasses 13 km (8 mi) of the Lower Coosa River channel, extending from Alabama State Highway 111 bridge, upstream to Jordan Dam, Elmore County, Alabama. This river reach is within the historic range of fine-lined pocketbook, southern clubshell, Alabama moccasinshell, Coosa moccasinshell, ovate clubshell, southern pigtoe, triangular kidneyshell, upland combshell, and southern acornshell. (Johnson, 2002; Pierson, 1991a).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the southern pigtoe (Pleurobema georgianum) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: All mussels are filter feeders. Oxygen-bearing water and food are drawn into the incurrent siphon, and waste-carrying water is simultaneously passed out the excurrent siphon. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS, 2000).

Reproduction Narrative

Adult: Host fish have been identified as Alabama shiner, blacktail shiner, and tricolor shiner (P. Johnson pers. Comm., 2002) (USFWS, 2008). While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of 20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years (USFWS, 2000).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015); fragmented (see population narrative)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits high quality rivers (small rivers to large streams) in shoals and runs with stable gravel and sandy-gravel substrates (USFWS, 2000) (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (Natureserve, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (Natureserve, 2015).

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Species Trends:

Unknown (USFWS, 2008)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015); > 800 (USFWS, 2008)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). Threats are compounded by their restricted range and low numbers. The three species are vulnerable to random catastrophic events (e.g., flood scour, drought, toxic spills, etc.). Limited range and low numbers also make the species vulnerable to land use changes within the Conasauga River watershed that would result in increases in non-point source pollution impacts (USFWS, 2003). The historic range of Pleurobema georgianum included the Coosa River and its tributaries in Alabama, Georgia, and Tennessee (USFWS, 2000; 2004). Museum records indicate its presence in the Coosa River, Shoal Creek, and the Chatooga and Conasauga rivers. Recently (1987-1991) known from just a handful of records (USFWS, 1993). Pleurobema nucleopsis, now considered a synonym, is known historically in the Coosa River basin in Georgia from the Etowah River drainage but has not been collected there recently and is presumed extirpated (Williams and Hughes, 1998). The University of Michigan Museum of Zoology maintains collected specimens labeled Pleurobema nucleopsis from the Conasauga River (Murray and Whitfield Cos.), Coosawattee River (Murray Co.), Etowah River in Georgia (the type locality); and Terrapin Creek (Cherokee Co.), Little River (Cherokee Co.), Cahaba River (Bibb, Jefferson, Shelby, and other Cos.), Beeswax Creek (Shelby Co.), Buck Creek (Shelby Co.), and Coosa River (Shelby and other Cos.) in Alabama. Pleurobema troschelianum, now considered a synonym, is known historically from the Conasauga and Coosawattee River drainages (Williams and Hughes, 1998) plus the Conasauga River in Tennessee and Georgia, the Chatooga, Coosawatee and Oostanaula rivers and Coahutta Creek in Georgia, and the Middle Coosa River and Terrapin, Shoal, and Hatchet creeks in Alabama (USFWS, 1999; 2003). This species has experienced a long-term decline of 50-70%. The range extent of this species is 100 - 400 square miles, with an unknown population size. There are 6 - 20 occurrences, with no occurrences having good viability/integrity (NatureServe, 2015). The status of the species is unknown, based on the 2007 Recovery Data call. Warren et al. (2004) estimated the Shoal Creek population to consist of 800 individuals; this is likely the largest remaining population of the species (USFWS, 2008).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species (Neves et al., 1997). The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin (Neves et al., 1997). Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a molluskeating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a

considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: All populations of this species are affected by and susceptible to stochastic and chronic events such as spills, drought and/or landuse runoff (USFWS, 2008).

Recovery

Reclassification Criteria:
Reclassification does not appear to be a realistic goal for any this species at this time (USFWS, 2000).

Delisting Criteria:
1) At least 6 populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (Factors A and E). 2) At least four (4) populations (as defined in Criteria 1) occupy four of the six HUC8 watersheds (Conasauga, Coosawattee, Oostanaula, Upper Coosa, Middle Coosa, and Lower Coosa), and one (1) population occupies the main stem of the Oostanaula or the Coosa River to protect against extinction from catastrophic events and maintain adaptive potential. a) One (1) additional population (as defined in Criteria 1) of Coosa moccasinshell occupies the Cahaba, Upper Black Warrior, or Lower Black Warrior HUC8. 3) Threats have been addressed and/or managed to the extent that the species will remain viable

into the foreseeable future (Factors A, C, D, and E) (USFWS, 2019).

Recovery Actions:

- Protect habitat integrity and quality (USFWS, 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS, 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Develop measurable recovery criteria (USFWS, 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS, 2008).
- Develop and implement plan to describe and monitor habitat conditions where the species survives (USFWS, 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS, 2008).
- Work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson, Mississippi

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson, Mississippi.

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

USFWS. 2019. Coosa moccasinshell and Southern pigtoe Amendment 1 to the U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Pleurobema gibberum* (Cumberland pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 5/7/1991; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

This small freshwater mussel (rarely exceeds 60 millimeters in length) has a triangular, compressed, somewhat heavy shell. The shell's outer surface on young individuals is a yellowish-brown color; adults have a dark mahogany shell. The inside of the shell is a distinctive peach to orange color (Anderson 1990) (USFWS, 1991).

Taxonomy

Based on DNA analyses, Unio subplana Conrad, 1837, was found to be genetically indistinguishable from Fusconaia masoni (Conrad, 1834) (Bogan et al., unpublished data, in Williams et al., 2008). Since U. subplana is the type species of Lexingtonia, the genus Lexingtonia is considered a junior syonym of Fusconaia (Williams et al., 2008). The next available generic name for barnesiana and dolabelloides is Pleuronaia Frierson, 1927. Pleurobema gibberum was also found to belong to the Pleuronaia clade (see Williams et al., 2008). (NatureServe, 2015). The Service published a direct final rule on February 17, 2022 (87 FR 8960) with an effective date of May 18, 2022, to revise the taxonomy of the Cumberland pigtoe to Pleuronaia gibber. The accepted species name at the time of listing (1991) was Cumberland pigtoe (Pleurobema gibberum); however, molecular studies by Campbell et al. (2005) and Campbell and Lydeard (2012) supported a reassignment of Pleurobema gibberum to the genus Pleuronaia. Additionally, Williams et al. (2017) corrected the gender agreement of the specific name of Pleuronaia gibberum to gibber. The best available information continues to indicate that the species is a valid entity (USFWS, 2022).

Historical Range

This species is endemic to the Caney Fork River system in Tennessee. It may have once been widespread in the system.; (NatureServe, 2015)

Current Range

It now occurs in isolated sections of five tributaries: the Barren Fork, Calfkiller River, Cane Creek, Hickory Creek, and the Collins River (USFWS, 1991; Parmalee and Bogan, 1998).; (NatureServe, 2015)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Specific food habits of the Cumberland pigtoe are unknown, but it likely feeds on food items similar to those consumed by other freshwater mussels. Freshwater mussels are known to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924), which they filter out of the water (USFWS, 1991).

Reproduction Narrative

Adult: This species releases all conglutinates (composed primarily of unfertilized eggs; an adaptive strategy) by early to mid August each year (short-term brooders). It is gravid in late June through August. Fish hosts include telescope shiners (Notropis telescopus) and striped shiners (Luxilus chrysocephales) as marginal hosts (only 1 of 19 metamorphosed) (Layzer et al., 2003) (NatureServe, 2015). Conglutinates examined by Layzer et al. (2003) contained 3 - 6 glochidia (USFWS, 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015); fragmented (see population narrative)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits small to medium rivers in riffle areas with sand and gravel substrates and relatively shallow depths (Gordon and Layzer, 1989). Individuals collected by Layzer et al. (2003) were almost always observed completely embedded in the streambed with the posterior margins of their shells flush with the substrate surface. Most were found in sand, a few in a mixture of sand, gravel, and small cobble. The environmental specificity of this species is narrow and it is highly vulnerable. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). This species is typically found in reaches with moderately strong currents and depths ranging from 10 cm to 1 meter (Anderson 1990; Bogan and Parmalee 1998) (USFWS, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Uncertain (USFWS, 2015)

Species Trends:

Uncertain (USFWS, 2015)

Number of Populations:

7 (USFWS, 2022)

Population Size:

Unknown (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Populations sizes are small and in short reaches which are physically isolated from each other by impoundments and unsuitable habitat, recolonization of any extirpated population would be unlikely without human intervention. Natural gene flow is impeded severely and genetic viability of the remaining populations is questionable (USFWS, 1991). This species was formerly widespread in the Caney Fork system, but now occurs only in short reaches of five tributaries. Prior to the construction of Rock Island Reservoir in the 1910's typical habitat for this species was more common and the species was likely much more widely distributed within the Caney Fork system than available records indicate (USFWS, 1991). There are 5 extant populations. This species has experienced a long-term decline of 70-90%. The range extent is less than 40 square miles, with an unknown population size. (NatureServe, 2015). Natural gene flow among populations is no longer possible because stream reaches are physically isolated from each other. Recent and long-term monitoring data are not avialable to establish population trends; therefore, the status of the Cumberland pigtoe is currently considered uncertain (USFWS, 2015). Cane Creek –The Cumberland pigtoe population in Cane Creek is small but resilient with evidence of recent recruitment and higher numbers found (18 individuals in a recent effort) near and upstream of the Sweetgum community (upstream of area impounded by Great Falls Dam) (Simmons 2021). Simmons (2021) indicated that substrates downstream of Sweetgum are significantly embedded with sediment and reported finding only one live specimen in the downstream habitat. Although the known extent of habitat occupied in Cane Creek is rather limited, this population remains viable. Calfkiller River - Simmons (2021) found only two live Cumberland pigtoe mussels in the Calfkiller River since 2014 despite extensive and focused search efforts (over 56 hours). Two additional specimens of the species were documented by the author of this review and Andy Ford (Service) in the Calfkiller River in 2022. All four mussels were larger individuals and may represent an aging and non-recruiting population. Sediment deposition was also documented during recent inspections at the surveyed sites and may indicate periodic or chronic pollutant releases, with subsequent effects to the mussel. The Calfkiller River population appears to be exhibiting continued impairment at the level observed during the latest status review (Service 2015). Collins River – Recent surveys by Simmons (2021) resulted in findings of the Cumberland pigtoe at lower densities than historically reported, though it still represents the most resilient population in terms of numbers, recent recruitment, and occupied stream miles. Impairment was noted in substrate embeddedness levels and nutrient enrichment (algal blooms); additionally, there has been increased water withdrawal (likely by adjacent nursery operations) (Simmons 2021). Habitat remains relatively intact in the upper reaches of the Collins River (especially upstream of the Grundy County line), but more impacted downstream of McMinnville (Warren County). Overall, integrity of the Collins River appears to have declined since 2001 in terms of the species' density and habitat conditions, especially along the middle to lower reaches of the river. Hickory Creek - Simmons (2021) found four live and one fresh-dead Cumberland pigtoe in Hickory Creek in 2021. He surveyed a site on West Fork Hickory Creek without finding this species, and higher sediment levels were observed relative to that of Hickory Creek's substrate sediment level. This population appears to have maintained a similar level of health since survey efforts in 2004 and the most recent status review (Service 2015), but habitat degradation is of concern in portions of the watershed. Barren Fork of Collins River, including Witty Creek - Simmons (2021) found six live Cumberland pigtoes in the Barren Fork at the same site where Ahlstedt et al. (2004) had also found six individuals in 2004, and also documented a slight range extension by documenting two live individuals of the species at a site just upstream of McMinnville in a reach not surveyed previously. However, suitable mussel habitat was sporadic at both locations as stable cobble/gravel/sand habitats were rare. Researchers from Tennessee Technological University collected a single Cumberland pigtoe from Whitty Creek in 2021. Overall, the Barren Fork population appears stable. Hills Creek - Simmons (2021) found only one live Cumberland pigtoe in Hills Creek at a site that was previously surveyed by Ahlstedt et al. (2004) in 2004, and the individual was old. The site was somewhat impaired, as the substrate was dominated by unstable, shifting piles of sand. Overall, like the Collins River watershed as a whole, health of the Hills Creek population appears to have declined since 2004. Rocky River and Caney Fork mainstem - No Cumberland pigtoes have been documented from these waters. They are not considered to be occupied by the species, as Simmons (2021) confirmed its apparent absence during recent surveys (USFWS, 2022).

Threats and Stressors

Stressor: Habitat modification and degradation (USFWS, 2015)
Exposure:
Response:

Consequence:
Narrative: Great Falls Dam and its impoundment, Great Falls Reservoir, remain a threat to the Cumberland pigtoe due to the dam having isolated and fragmented its persisting populations. While known host fish species for the Cumberland pigtoe (telescope shiners and striped shiners) continue to persist in the upper Caney Fork River drainage, operation of Great Falls Dam creates a barrier to movement of fish populations in the upper Caney Fork River mainstem and its major tributaries. Great Falls Dam impounded several miles of the Caney Fork and lower Collins rivers, reducing the amount of suitable habitat available to the Cumberland pigtoe (Service 1992). The species has been unable to adapt to these habitat changes. Sedimentation from impoundment has vastly altered the shoal habitat inhabited by the species in areas inundated by the dam. Host fishes are also likely to be impacted by excessive sedimentation, as a result of the impoundment. Potential and actual threats include the following: pesticides, herbicides and fertilizers used by the plant nursery industry, water withdrawals for irrigation of nurseries could reduce habitat or degrade water quality during low flows, habitat alteration and destruction from gravel dredging; gravel dredging could increase siltation and water turbidity in downstream perennial reaches, siltation and agricultural runoff in the Collins River, acid drainage from historical coal mines in the Cumberland Plateau reaches of stream systems, logging of upland areas resulting in decreased aquifer recharge, changes in the annual hydrograph, and overland runoff to streams, water quality degradation and bank instability caused by livestock access, removal of riparian vegetation and encroaching streamside development, hydrologic alteration and habitat degradation in lower reaches of streams due to operation of Great Falls Reservoir (USFWS, 2015).

Stressor: Stochastic events (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Existing populations inhabit only short stream reaches, rendering them vulnerable to extirpation from stochastic events, such as chemical spills or drought. Such events could impact or eliminate one or more of the individual populations (USFWS, 2015).

Recovery

Reclassification Criteria:
1. Through protection of existing populations and through successful establishment of reintroduced populations or the discovery of additional populations, a total of four distinct viable populations exist. The populations shall be distributed within the Upper Caney Fork River system and can include the present populations or newly discovered or created populations (USFWS, 2015).

2. One distinct naturally reproduced year class exists within each of the four populations. The year class must have been produced within 5 years prior to the time the species is reclassified from endangered to threatened. Within 1 year of the downlisting data, gravid females and the mussel's host fish must be present in each populated river reach (USFWS, 2015).

3. Biological and ecological studies have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the four populations (USFWS, 2015).

Recovery Priority Number: 5

Delisting Criteria:
1. Through protection of existing populations and successful establishment of reintroduced populations, a total of six distinct viable populations exist. These populations must be separated to the extent that it is unlikely that a single event would eliminate or significantly reduce more than one of these populations (USFWS, 2015).

2. Two distinct naturally reproduced year classes exist within each of the six populations. Both year classes must have been produced within 10 years, and one year class within 5 years, of the recovery date. Within 1 year of the recovery date, gravid females and the mussel's host fish must be present in each river (USFWS, 2015).

3. Studies of the mussel's biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful, as evidenced by an increase in population density and/or an increase in the length of the river reach inhabited by each of the six populations (USFWS, 2015).

4. No foreseeable threats exist that would likely threaten the survival of any of these six populations (USFWS, 2015).

5. Where habitat has been degraded, noticeable improvements in water and substratum quality have occurred (USFWS, 2015).

Recovery Actions:
- Determine threats and alleviate those that threaten the species’ existence (USFWS, 1991).
- Utilize existing legislation/regulations to protect the species (USFWS, 1991).
- Search for new populations and monitor existing populations (USFWS, 1991).
- Develop and utilize an information/education program (USFWS, 1991).
- Determine the species’ life history requirements (USFWS, 1991).
- Through reintroduction and protection, establish six viable populations (USFWS, 1991).
- Develop and implement cryopreservation protection of the species (USFWS, 1991).
- Use TDEC's most current 303(d) list and any other information available to determine specific pollutants and causative factors impacting the Cumberland pigtoes and/or its habitat, and identify sources of pollutants to prioritize sites for working with private landowners to reduce such threats. Additionally, identify major landowners in the drainages occupied by cumberland pigtoes who should be targeted for cooperative conservation efforts to prevent future risk of threats associated with anticipated land uses (USFWS, 2015).
- Continue conducting life history studies of the cumberland pigtoe, particularly studies to assist in determining effective population sizes for the species. Such studies would involve researching factors which influence effective population size, including sex ratio, length of reproductive life, fecundity, extent of exchange of genetic material, and other life history aspects (USFWS, 2015).
- Use existing state and federal regulations and develop partnerships (local watershed projects) with federal and state agencies, local governments, nurserymen, agricultural

groups, coal mining interests, conservation organizations, and local landowners and other interested individuals to protect the species and its habitat (USFWS, 2015).
- Conduct a population structure and genetic diversity study of the Cumberland pigtoes. Such a study would determine the level of gene flow among seemingly isolated populations to assist in defining individual populations and determine the amount of inbreeding (levels of genetic diversity) within populations (USFWS, 2015).
- Resurvey stream reaches in the upper Caney Fork River drainage previously surveyed by Ahlstedt et al. 2004, in addition to surveying the Falling water River, to determine and update the status of the cumberland pigtoes. These surveys should be conducted in conjunction with surveys to quantify the amount of suitable habitat for the species (USFWS, 2015).
- Assure that all Cumberland mussel collections and observations are represented by records in databases maintained by TVA's Regional Natural Heritage Project and Tennessee Division of Natural Areas' - Natural Heritage program (USFWS, 2015).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES Implement conservation actions recommended in the Cumberland pigtoe Recovery Plan (Service 1992), the Tennessee Wildlife Action Plan (https://www.tn.gov/content/tn/twra/wildlife/actionplan.html), or the National Strategy for the Conservation of Native Freshwater Mollusks (FMCS 2016) (USFWS, 2022).

References

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

U.S. Fish and Wildlife Service. 1991. Cumberland Pigtoe Mussel (Pleurobema aibberum) Recovery Plan. Atlanta, Georgia. 20 pp. USFWS. 2022. Cumberland pigtoe (Pleuronaia gibber) Status Review: Summary and Evaluation. Tennessee Ecological Services Field Office. Cookeville, Tennessee. 15 pages.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS. 2015. Cumberland Pigtoe (Pleurobema gibberum = Pleuronaia gibberum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Tennessee Ecological Services Field Office, Cookeville, Tennessee

U.S. Fish and Wildlife Service. 1991. Cumberland Pigtoe Mussel (Pleurobema gibberum) Recovery Plan. Atlanta, Georgia. 20 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia

USFWS 2015. Cumberland Pigtoe (Pleurobema gibberum = Pleuronaia gibberum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Tennessee Ecological

Services Field Office, Cookeville, Tennessee. USFWS. 2022. Cumberland pigtoe (Pleuronaia gibber) Status Review: Summary and Evaluation. Tennessee Ecological Services Field Office. Cookeville, Tennessee. 15 pages.

USFWS. 2015. Cumberland Pigtoe (Pleurobema gibberum = Pleuronaia gibberum)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Tennessee Ecological Services Field Office, Cookeville, Tennessee.

USFWS 2015. Cumberland Pigtoe (Pleurobema gibberum = Pleuronaia gibberum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Tennessee Ecological Services Field Office, Cookeville, Tennessee.

USFWS 2015. Cumberland Pigtoe (Pleurobema gibberum = Pleuronaia gibberum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region, Tennessee Ecological Services Field Office, Cookeville, Tennessee

USFWS. 2022. Cumberland pigtoe (Pleuronaia gibber) Status Review: Summary and Evaluation. Tennessee Ecological Services Field Office. Cookeville, Tennessee. 15 pages.

SPECIES ACCOUNT: *Pleurobema hanleyianum* (Georgia pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2010; Southeast Region (R4)

Physical Description

The shell of the adult Georgia pigtoe reaches about 50 to 65 millimeters (mm) (2 to 2.5 inches (in)) in length. It is oval to elliptical and somewhat inflated. The posterior ridge is low and evenly rounded when evident. The anterior end is rounded, while the posterior margin is bluntly pointed below. Dorsal and ventral margins are curved, and the beaks rise slightly above the hinge line. The periostracum (membrane on the surface of the shell) is yellowish-tan to reddish-brown and may have concentric green rings. The beak cavity is shallow, and the shell interior is white to dull bluish-white (Parmalee and Bogan 1998, Williams et al. 2008) (USFWS, 2014).

Taxonomy

The Georgia pigtoe (Pleurobema hanleyianum) is a freshwater mussel in the family Unionidae (Figure 1). It was described in 1852 by I. Lea as Unio hanleyianum from the Coosawattee River in Georgia. It was placed in the genus Pleurobema by Simpson in 1900. The uniqueness of the Georgia pigtoe has been verified both morphologically (Williams et al. 2008) and genetically (Campbell et al. 2008) (USFWS, 2014).

Historical Range

The Georgia pigtoe was historically found in large creeks and rivers of the Coosa River drainage of Alabama, Georgia, and Tennessee (Johnson and Evans 2000; Williams et al., 2008). There are historical reports or museum records of the Georgia pigtoe from Tennessee (Conasauga River in Polk and Bradley Counties), Georgia (Conasauga River in Murray and Whitfield Counties, Chattooga River in Chattooga County; Coosa River in Floyd County, Etowah River in Floyd County, Coahulla Creek in Whitfield County), and Alabama (Coosa River in Cherokee County, Terrapin Creek in Cherokee County, Little Canoe and Shoal Creeks in St. Clair County, Morgan Creek in Shelby County, and Hatchet Creek in Coosa County) (Florida Museum of Natural History Malacology Database (FLMNH) in litt. 2006; Gangloff 2003). Based on these historical records, the range of the Georgia pigtoe included more than 480 km (300 mi) of river and stream channels. Additional historical Coosa River tributary records credited to Hurd (1974) (for example, Big Wills, Little Wills, Big Canoe, Oothcalooga, Holly Creeks) have been found to be misidentifications of other species (Gangloff in litt. 2006) (USFWS, 2014)

Current Range

The Georgia pigtoe is currently known from a few isolated shoals in the Upper Conasauga River in Murray and Whitfield Counties, Georgia, and in Polk County, Tennessee (Johnson and Evans 2000, Evans 2001) (Figure 2). All recent collection sites occur within a 43-km (27-mi) reach of the river. Within this reach, the Georgia pigtoe is very rare (Johnson and Evans 2000), and no demography estimates are available (USFWS, 2014).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 11/2/2010.

Legal Description
On November 2, 2010, the U.S. Fish and Wildlife Service designated critical habit for the Georgia pigtoe mussel (Pleurobema hanleyianum)(and two other species) under the Endangered Species Act of 1973, as amended (75 FR 67512 - 67550). The critical habitat includes approximately 148 kilometers (km) (92 miles (mi)) of stream and river channels as critical habitat for the Georgia pigtoe in Bradley and Polk Counties in Tennessee, Murray and Whitfield Counties in Georgia , and Cherokee, Coosa and Clay Counties in Alabama.

Critical Habitat Designation
Three units are designated as critical habitat for the Georgia pigtoe (GP 1, GP 2, and GP 3). These areas encompass approximately 148 kilometers (km) (92 miles (mi)) of stream and river channels in Bradley and Polk Counties, Tennessee, Murray and Whitfield Counties, Georgia , and Cherokee, Coosa and Clay Counties, Alabama. Critical habitat includes only the stream channel within the ordinary high water line (75 FR 67512 - 67550).

Unit GP 1: Conasauga River, Bradley and Polk Counties, Tennessee, and Murray and Whitfield Counties, Georgia. Unit 1 for the Georgia pigtoe includes 52 km (32 mi) of the Upper Conasauga River from the confluence of Minnewaga Creek near Willis Springs, Polk County, Tennessee, downstream to U.S. Highway 76 in Murray and Whitfield Counties, Georgia. Critical habitat includes the stream channel within the ordinary high water line only. In Tennessee, the riparian landowner owns the stream bottom to the middle of the channel. Therefore, 5 km (3 mi) of GP 1 in Tennessee is privately owned. In Georgia, the State owns navigable stream bottoms within the ordinary high water line, and the Conasauga River is considered navigable. Therefore, the State of Georgia owns 47 km (29 mi) of Unit GP 1. The Georgia pigtoe has been collected from three shoals within the reach of the Conasauga River identified as GP 1, one located at each end of the reach and one site in between (Johnson and Evans 2000, p. 106; Evans 2001, pp. 33–34). Therefore, we consider the entire reach of the Conasauga River that composes GP 1 as occupied. Other shoals within the reach continue to be inhabited by a diverse mussel community, including the endangered triangular kidneyshell and southern pigtoe and the threatened fine-lined pocketbook. These species historically co-occurred in the same shoal habitats with the Georgia pigtoe, they have similar habitat requirements, and their persistence indicates the presence of PCEs 1, 2, 3, and 4 for the Georgia pigtoe. The persistence of the Georgia pigtoe within three shoals of this reach also indicates the presence of an appropriate fish host (PCE 5). This small population of Georgia pigtoe is at a high risk of extinction due to changes in flow, habitat or water quality, and stochastic events such as drought. Threats to the Georgia pigtoe and its habitat that may require special management of the PCEs include the potential of anthropogenic activities (such as channelization, impoundment, and channel excavation) that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal; the potential of significant alteration of water chemistry or water quality; and the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, off-road vehicle use, and other watershed and floodplain disturbances that release sediments or nutrients into the water.

Unit GP 2: Terrapin Creek and Coosa River, Cherokee County, Alabama Unit 2 for the Georgia pigtoe includes 24 km (15 mi) of Terrapin Creek from Alabama Highway 9 downstream to its confluence with the Coosa River, and 11 km (7 mi) of the Coosa River from Weiss Dam downstream to approximately 1.6 km (1 mi) below the confluence of Terrapin Creek in Cherokee County, Alabama. The State of Alabama owns navigable stream bottoms within the ordinary high water line, and both Lower Terrapin Creek and the Coosa River are considered navigable streams. The Georgia pigtoe is not currently known to occur in Terrapin Creek or the Coosa River. However, Unit 2 is essential to the conservation of the Georgia pigtoe due to the high potential for stochastic events in the Conasauga River (the only extant population of Georgia pigtoe), and the need to reestablish the species within other portions of its historical range in order to reduce threats from stochastic events. Lower Terrapin Creek and the Coosa River are within the species' historical range, and we consider them to be essential to the conservation of the Georgia pigtoe. Terrapin Creek flows into the Coosa River below Weiss Dam. Terrapin Creek continues to support a diverse mollusk assemblage, including the endangered southern pigtoe, a closely related species that co-occurs with the Georgia pigtoe in the Conasauga River, indicating the presence of PCEs 1, 2, 3, and 4. The endangered southern clubshell, the threatened fine-lined pocketbook, and other mussel and snail species requiring PCEs 1, 2, 3, and 4 similar to the Georgia pigtoe continue to survive in the Coosa River just below the confluence of Terrapin Creek. Additionally, a diverse fish fauna, including potential fish hosts for the Georgia pigtoe (PCE 5), is known from Terrapin Creek and Coosa River. Minimum flows from Weiss Dam into the Coosa River will be implemented upon completion of the Alabama Power Company Coosa River hydropower relicensing process with FERC (Weiss Bypass Working Group 2005, pp. 6–8), which is currently in progress. These minimum flows will improve the PCEs necessary for the survival of the Georgia pigtoe in the Coosa River, particularly above the confluence with Terrapin Creek. Because the minimum flows will originate from the large reservoir impounded by Weiss Dam, there is little threat of nonpoint source pollution and reduced potential of stochastic threats, such as drought and spills. ADCNR recognizes this reach of the Coosa River as having high conservation potential for imperiled mollusks in Alabama and is planning to reintroduce imperiled mollusks, including the Georgia pigtoe, following implementation of minimum flows. Over the past few decades, changes in land uses, use of best management practices for agriculture and forestry activities in the watershed, and implementation of State water quality standards resulted in improved water quality and shoal habitats in Terrapin Creek. The Mobile River Basin Mollusk Restoration Committee (2008, p. 40) recognizes Terrapin Creek as an appropriate reintroduction opportunity for the Georgia pigtoe.

Unit GP 3: Hatchet Creek, Coosa and Clay Counties, Alabama. Unit 3 for the Georgia pigtoe includes approximately 66 km (41 mi) of Hatchet Creek, extending from Clay County Road 4, Clay County, downstream to the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama. The State of Alabama owns navigable stream bottoms within the ordinary high water line, and Hatchet Creek is considered navigable. The Georgia pigtoe does not currently occupy Hatchet Creek. However, historical records of the species show its presence in this stream from the stream's confluence with the Coosa River, Coosa County, upstream into Clay County, Alabama. An extensive reach of Hatchet Creek is occupied by the threatened fine-lined pocketbook, along with other mollusk species that currently or historically co-occur with Georgia pigtoe, indicating the presence of PCEs 1, 2, 3, and 4. A diverse fish fauna, including several potential fish hosts for the pigtoe (PCE 5), is also known to inhabit Hatchet Creek. Water quality and shoal habitats in this stream have improved relative to past historical conditions due to changes in land uses, implementation of best management practices in agriculture and forestry activities in the watershed, and implementation of State water quality standards. Due to these improvements, Hatchet Creek has been designated as an Outstanding Alabama Water, which also provides for increased water quality protections. The Mobile River Basin Mollusk Restoration Committee (2008, p. 40) recognizes Hatchet Creek as having high conservation potential for reintroduction of the Georgia pigtoe. Re-establishing Georgia pigtoe in Hatchet Creek will significantly reduce the level of stochastic threats to the species' survival and is essential to the conservation of the species. We do not know which specific shoals or reaches of Hatchet Creek may be capable of supporting the Georgia pigtoe. Therefore, we have designated all apparently suitable habitat within the historical range of the species in Hatchet Creek as critical habitat essential to the conservation of Georgia pigtoe.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Cherokee, Coosa, and Clay Counties, Alabama; Murray and Whitfield Counties, Georgia; and Bradley and Polk Counties, Tennessee. The primary constituent elements (PCEs) of critical habitat for the Georgia pigtoe are the habitat components that provide:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) A hydrologic flow regime (the magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species is found. Unless other information becomes available, existing conditions at locations where the species occurs will be considered as minimal flow requirements for survival.

(iii) Water quality (including temperature, pH, hardness, turbidity, oxygen content, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387).

(iv) Sand, gravel, cobble, boulder, or bedrock substrates with low to moderate amounts of fine sediment and attached filamentous algae.

(v) The presence of fish host(s) for the Georgia pigtoe (species currently unknown). Diverse assemblages of native fish will serve as a potential indication of presence of host fish.

Special Management Considerations or Protections

Critical habitat does not include manmade structures existing on the effective date of this rule and not containing one or more of the PCEs, such as buildings, bridges, aqueducts, airports, and roads, and the land on which such structures are located.

Various activities in or adjacent to each of the critical habitat units described below may affect one or more of the PCEs. Features in all of the critical habitat units may require special management due to threats posed by land-use runoff and point- and nonpoint-source water pollution.

Federal activities that may affect the Georgia pigtoe include, but are not limited to, the carrying out or the issuance of permits for reservoir construction, stream alterations, discharges, wastewater facility development, water withdrawal projects, pesticide registration, mining, and road and bridge construction. It has been the experience of the Service, however, that nearly all section 7 consultations have been resolved so that the species have been protected and the project objectives have been met

Life History

Feeding Narrative

Adult: Unionid mussels, such as the Georgia pigtoe, filter-feed on algae, detritus, and bacteria from the water column (USFWS, 2014).

Reproduction Narrative

Adult: The larvae of most unionid mussels are parasitic, requiring a period of encystment on a fish host before they can develop into juvenile mussels. The fish host and glochidia (parasitic larvae) of Georgia pigtoe are currently unknown (USFWS, 2014).

Habitat Narrative

Adult: Little is known about the habitat requirements or life history of the Georgia pigtoe; however, it is currently found in shallow runs and riffles with strong to moderate current and coarse sand–gravel–cobble bottoms (USFWS, 2014).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2014 and NatureServe, 2015).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS, 2014 and NatureServe, 2015).

Dispersal

Adult: Low (inferred from USFWS, 2014 and NatureServe, 2015).

Immigration/Emigration

Adult: Unlikely (inferred from USFWS, 2014 and NatureServe, 2015).

Dispersal/Migration Narrative

Adult: Mobility, Non-migratory, dispersal and immigration/emigration are inferred based on taxonomy and habitat (inferred from USFWS, 2014 and NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Number of Populations:

2 (USFWS, 2021

Population Size:

1-1000 (inferred from NatureServe, 2015 and USFWS, 2014)

Population Narrative:

Georgia pigtoe was thought to be extinct until surveys in 2000 found live individuals in the upper Conasauga River (USFWS, 2014). Short-term Trend: Decline of >70% NatureServe, 2015). Resiliency, representation and redundancy are inferred based on habitat and taxonomy (inferred from NatureServe, 2015 and USFWS, 2014).

Threats and Stressors

Stressor: Range curtailment (USFWS, 2014).
Exposure:
Response:
Consequence:
Narrative: The primary cause of range curtailment for has been modification and destruction of river and stream habitats, primarily by the construction of large hydropower dams on the Coosa River (USFWS, 2014).

Stressor: Dams and Impoundments (USFWS, 2014).
Exposure:
Response:
Consequence:
Narrative: Dam construction on the Coosa River had a secondary effect of fragmenting the ranges of aquatic mollusk species, leaving isolated habitats and relict populations separated by the dams as well as by extensive areas of uninhabitable, impounded waters. These isolated populations were left more vulnerable to, and affected by, natural events (such as droughts), runoff from common land-use practices (such as agriculture, mining, urbanization), discharges (such as municipal and industrial wastes), and accidents (such as chemical spills) that reduced population levels or eliminated habitat (Neves et al. 1997, U.S. Fish and Wildlife Service 2000) (USFWS, 2014).

Stressor: Water and Habitat Quality (USFWS, 2014).
Exposure:
Response:
Consequence:
Narrative: The disappearance of shoal populations of rough hornsnail, interrupted rocksnail, and Georgia pigtoe from unimpounded habitats in the Coosa River drainage is likely due to historical pollution problems. Pleurocerid snails and freshwater mussels are highly sensitive to water and habitat quality (Havlik and Marking 1987, Neves et al. 1997). Historical causes of water and habitat degradation in the Coosa River and its tributaries included drainage from gold mining activities, industrial and municipal pollution events, and construction and agricultural runoff (for example, Hurd 1974, Lydeard and Mayden 1995, Freeman et al. 2005) (USFWS, 2014).

Stressor: Climate Change (USFWS, 2014).
Exposure:
Response:
Consequence:

Narrative: Small population sizes and limited distribution of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail, make them more vulnerable to drought, severe storm events, and other potential effects of climate change. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (for example, Golladay et al. 2004, McLaughlin et al. 2002, Cook et al. 2004). During 2007-2008, a severe drought affected the Coosa River watershed in Alabama and Georgia. Streamflow for the Conasauga River at Tilton, Georgia, during September 2007, was the lowest recorded for any month in 69 years (U.S. Geological Survey 2007). Although the effects of the drought on the Georgia pigtoe, interrupted rocksnail, and rough hornsnail have not been quantified, mollusk declines as a direct result of drought have been documented (for example, Golladay et al. 2004, Haag and Warren 2008). Reduction in local water supplies due to drought is also compounded by increased human demand and competition for surface and ground water resources for power production, irrigation, and consumption (Golladay et al. 2004). Small population sizes and limited distribution of the Georgia pigtoe, interrupted rocksnail, and rough hornsnail, make them more vulnerable to drought and storm events (USFWS, 2014).

Recovery

Reclassification Criteria:
1. Maintain and where possible conduct efforts to improve the Conasauga River population of the Georgia pigtoe (USFWS, 2014).

2. Develop and implement a monitoring plan to evaluate population size in response to management actions (USFWS, 2014).

3. Develop a captive propagation program and establish an ark population to help support the Conasauga River population of the Georgia pigtoe (USFWS, 2014).

4. Conduct research, like identification of an appropriate fish host, that is important to gain better understanding of this mussel's life history (USFWS, 2014).

5. Identify, monitor, and where possible improve potential reintroduction sites in the historical range of the Georgia and reintroduce the species into these habitats (USFWS, 2014).

Delisting Criteria:
1) At least six (6) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (Factors A and E). 2) At least one (1) population (as defined in Criteria 1) occupies four of the six HUC8s watersheds (Conasauga, Coosawattee, Oostanaula, Upper Coosa, Middle Coosa, and Lower Coosa), and one (1) population occupies the main stem of the Oostanaula or the Coosa River to protect against extinction from catastrophic events and maintain adaptive potential (Factors A and E). 3) Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A, C, D, and E) (USFWS, 2019).

Recovery Actions:
- 1. Remaining riverine habitat currently known for each species has been monitored and protected. Recovery Tasks 1.1, 1.2, 1.3, 1.41- 1.45, 2.1, 2.2, 3.1, and 3.2 will contribute to this criterion. 2. Although critical habitat was designated at the time of listing, there is still

considerable information we do not know about the life history and specific habitat requirements for these species. Critical research and monitoring on life history and habitat requirements has been implemented. Recovery Tasks 1.1, 4.0, 5.1, 5.3, 5.4.1, and 5.42 will contribute to this criterion. 3. The range of each species includes three or more distinct drainages. This includes those locations where the species is known to occur. Recovery Tasks 7.1, 7.2, and 7.3 will contribute to this criterion (USFWS, 2014).

- There are no known threats to any of these species due to disease. There is no direct evidence at this time that predation is detrimentally affecting the Georgia pigtoe, interrupted rocksnail, or rough hornsnail. However, increasing their population sizes and ranges will reduce their vulnerability to threats of predation from natural or introduced predators. This is addressed under Factor A, above, and E, below (USFWS, 2014).
- Under the consultation requirements of the Endangered Species Act, existing regulatory mechanisms (e.g., the Clean Water Act and associated State Laws, Rivers and Harbors Act, etc.) afford consideration of the species when projects are reviewed. Information derived under Recovery Tasks 1.2, 1.3, 1.4.1-1.4.5, 2.1, and 2.2 will facilitate these consultations (USFWS, 2014).
- All threats affecting the Georgia pigtoe, interrupted rocksnail, or rough hornsnail, are influenced by their small population sizes and limited ranges. The following criteria shall serve to indicate a reduction in this threat: 1. Successful hatchery/captive propagation programs have been established for each species. Recovery Task 6.0 is essential to this criterion. 2. The range of each species has been extended to three or more distinct drainages. Recovery Tasks 7.1, 7.2, and 7.3 will contribute to this criterion. 3. Sustainable natural reproduction and recruitment has been demonstrated in each population. Recovery tasks 1.1, 2.1, 2.2, 3.1, 3.2, and 7.3 address this criterion.

Conservation Measures and Best Management Practices:

- • Conduct qualitative and quantitative surveys within known habitats and continue surveys in other areas to find additional populations, including documentation of local threats. Acquire brood stock for captive propagation and host fish trials. Conduct genetic and histology research to inform propagation and culture work and ensure fitness of reintroduced populations. Investigate and identify potential sites for the future reintroduction of captively reared individuals. Document specific life history and habitat needs; examine unknown components of life history and ecology, including identification of host fish and physiochemical parameters of the stream habitats used by the Georgia pigtoe. Work with local landowners to preserve the integrity of stream banks and riparian zones with known habitat, and mitigate problem areas with appropriate conservation and restoration practices. Restore Georgia pigtoe critical habitat through activities such as bank stabilization, riparian buffer maintenance/augmentation, adherence to best management practices, and other watershed-scale conservation efforts. Develop contingency plans to respond to a spill or natural disaster, or other stochastic event within or upstream of occupied habitat. (USFWS, 2021)

References

U.S. Fish and Wildlife Service. 2014. Recovery Plan for the Georgia pigtoe mussel, Interrupted rocksnail, and Rough hornsnail. Atlanta, Georgia. 55 pp

USFWS. 2010. Determination of Endangered Status for the Georgia Pigtoe Mussel, Interrupted Rocksnail, and Rough Hornsnail and Designation of Critical Habitat

Final Rule. 75 Federal Register 211, November 2, 2010 (Pages 67512-67549).

U.S. Fish and Wildlife Service. 2010. Endangered and Threatened Wildlife and Plants

Determination of Endangered Status for the Georgia Pigtoe Mussel, Interrupted Rocksnail, and Rough Hornsnail and Designation of Critical Habitat. Final rule. 75 FR 67512 - 67550 (November 2, 2010).

NatureServe Explorer (2015): An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 10, 2016).

NatureServe Explorer (2015): An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 10, 2016). USFWS. 2021. Georgia pigtoe (Pleurobema hanleyianum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 24 pp.

U.S. Fish and Wildlife Service. 2014. Recovery Plan for the Georgia pigtoe mussel, Interrupted rocksnail, and Rough hornsnail. Atlanta, Georgia. 55 pp.

USFWS. 2019. Amendment 1 to the Recovery Plan for the endangered Georgia pigtoe (Pleurobema hanleyianum).

USFWS. 2021. Georgia pigtoe (Pleurobema hanleyianum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 24 pp.

SPECIES ACCOUNT: *Pleurobema oviforme* (Tennessee clubshell)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

Attaining a maximum length of approximately 90 millimeters (mm) (4 inches (in)), the Tennessee clubshell is oval to triangular shaped and has a tawny to brown shell, usually with wide, broken green rays (USFWS, 2023)

Taxonomy

Medionidus conradicus, P. oviforme, and P. barnesiana belong to the family Unionidae, also known as the naiads or pearly mussels. North America contains the greatest diversity of freshwater mussels globally, comprising around 300 currently recognized species, with 29 species considered extinct and nearly 200 considered imperiled (Haag and Williams 2014, entire). This SSA follows the most recently published and accepted taxonomic treatment of North American freshwater mussels (Williams et al. 2017, entire). Recent studies have suggested potential genetic overlap between P. oviforme and the federally Endangered Pleurobema clava (Inoue et al. 2018, p. 698), and a potentially distinct form of P. oviforme may exist in the Little River in the upper Tennessee Basin (Schilling 2015, p. 105). Furthermore, the recovery plan and most recent 5-year review of P. clava acknowledges morphological and geographic overlap between P. clava and P. oviforme in the Tennessee and Cumberland River systems (Service 1994, p. 6; Service 2009, p. 11). Because no formal taxonomic changes have been published due to the limited data available, the present analysis treats P. oviforme as a valid species. Genetic analyses are ongoing (J. Jones and C. Morrison 2020, personal communication), and future assessments should carefully consider any taxonomic information published after the writing of this SSA report (USFWS, 2020).

Current Range

It occurs in the Tennessee and Cumberland River drainages in Alabama, Georgia, Kentucky, North Carolina, Tennessee, and Virginia (USFWS, 2023)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

<u>Adult:</u> Broadcast spawning

Lifespan

<u>Adult:</u> 30-50 years (USFWS, 2023)

Breeding Season

<u>Adult:</u> spawns in the spring and releases glochidia mid-July through early August (USFWS, 2023).

Key Resources Needed for Breeding

Adult: Host fish (Minnows)

Other Reproductive Information

Adult: In total, 10 host fish species in the minnow and darter families have been documented by observations of either attachment or metamorphosis of glochidia (Service 2020, pp. 5–6). As a short-term brooder, the Tennessee clubshell spawns in the spring and releases glochidia mid-July through early August (USFWS, 2023). The Tennessee clubshell has a lifespan of 30 years on average but may live to 50 years. Age at maturity ranges from 4 to 6 years. In total, 10 host fish species in the minnow and darter families have been documented by observations of either attachment or metamorphosis of glochidia (Service 2020, pp. 5–6). As a short-term brooder, the Tennessee clubshell spawns in the spring and releases glochidia mid-July through early August. (USFWS< 2023)

Reproduction Narrative

Adult: Freshwater mussels, including the three species that are the subjects of this proposed rule, have a complex reproduction process involving parasitic larvae, called glochidia, that are wholly dependent on host fish. Mussels release sperm into the water column, which is taken in by the female, wherein fertilization and development of glochidia occurs in a restricted portion of the gills, called the brood pouch or marsupium. When mature, the glochidia are released to the water column to attach on the gills, head, or fins of fishes. Glochidia die if they fail to attach to a host fish, attach to an incompatible fish species, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 599). Once attached to the host, glochidia draw nutrients from the fish's tissue as they develop (Arey 1932, pp. 214–215). Time to development, from attachment of glochidia to maturation, ranges from just over 1 week to 6 weeks or more (Parmalee and Bogan 1998, p. 8). Depending on the species, mussels are either short-term or long-term brooders. In short-term brooders, fertilization occurs in the spring or summer and glochidia are released shortly after they are fully developed. In long-term brooders, fertilization occurs in late summer or fall, and developed glochidia are held over winter and released in the following spring or summer (Haag 2012, pp. 39–40). Mature glochidia drop off their hosts and, if they settle in suitable habitat on the stream bottom, continue the remainder of their existence as freeliving mussels. Newly released glochidia are juveniles that are reproductively immature but otherwise resemble adults, with both halves (valves) of the shell developed and poised for growth (USFWS, 2023)

Habitat Type

Adult: Aquatic

Habitat Narrative

Adult: Favoring moderately swift currents, it is found in riffles and shoals of small streams to large rivers, in a mixture of sand, gravel, and cobble substrates (USFWS, 2023).

Dispersal/Migration

Population Information and Trends

Species Trends:

Declining

Number of Populations:

Currently, it occupies 35 to 64 watersheds, compared to 147 historically (USFWS, 2023)

Population Narrative:

The Tennessee clubshell historically occurred throughout the Tennessee and Cumberland River basins. Currently, it occupies 35 to 64 watersheds, compared to 147 historically, reflecting a range reduction of 58 to 76 percent. Most extant populations of the species are classified as low condition (28), with only three populations classified as high condition and four populations classified as medium condition, indicating species condition is currently low (see table 3, above). Rangewide, there are three redundant populations with high resiliency, which are likely to withstand the effects of stochastic events, and five redundant populations with medium resiliency, which may withstand the effects of a stochastic event. The 28 low-condition (low resiliency) populations have little capacity to withstand the effects of a stochastic event and do not contribute to species redundancy or the species' capacity for withstanding catastrophic events. While the Tennessee clubshell persists in the Tennessee River basin, it is on the verge of extirpation from the entire Cumberland River basin, with only 5 low-condition populations (low resiliency) and 16 extirpated populations. Extirpation of the species from this basin would result in a 50 percent loss in representation, as the Tennessee clubshell would be lost from one of the two major ecological settings (representation units) in its range. Representation has been further diminished by reductions in connectivity between mainstem and tributary streams, which contribute to reduced size and genetic isolation of Tennessee clubshell populations (USFWS, 2023)

Threats and Stressors

Stressor: Large Impoundments (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Our analysis identified large impoundments (indicated by reservoir surface area) as a rangewide threat to the three mussel species. The Tennessee Valley Authority operates 31 large dams in the Tennessee River system and one large dam (Great Falls Dam) in the Cumberland system (TVA Recreation Map website, 2023) and the U.S. Army Corps of Engineers operates 10 large dams in the Cumberland system (USACE Nashville District website, 2023). The effects of dams on aquatic habitats and freshwater mussels are well-documented (Watters 2000, p. 261), and extinction and extirpations of North American freshwater mussels can be traced to impoundment and inundation of riffle habitats in all major river basins of the central and eastern United States (Haag 2009, p. 107). Dams disrupt population connectivity and alter water quality. After a dam has been constructed, upstream the channel becomes deeper, flow decreases dramatically, and fine sediments accumulate on the channel bottom, which eliminates shoal and riffle habitats needed by the three mussel species, as well as many others, and their host fishes. Downstream of dams, natural flow regimes are disrupted by alternating low flow releases and pulses of scouring flows (Hardison and Layzer 2001, p. 79), reduced water temperatures, reduced dissolved oxygen, and changes in fish assemblages. Mussels may survive in cold tailwaters but may not be able to reproduce, as was shown for native washboard mussels (Megalonaias nervosa) in the mainstem Cumberland River (Heinricher and Layzer 1999, entire). In a

Cumberland River tributary, Caney Fork, the extirpation of several mussel species, including Cumberland moccasinshell, was attributed mainly to cold tailwater temperatures from Center Hill Dam (completed in 1948) and alteration of channel morphology from peaking flows, and no live mussels were found within 7.5 mi (12 km) of the dam outfall (Layzer et al. 1993, pp. 69–70) (USFWS, 2023).

Stressor: Developed Land Use/Urbanization (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: For all three mussel species, development and urbanization contribute to habitat degradation and loss. Freshwater mussel populations may experience reduced abundance, species richness, reproduction, growth, and survival stemming from the impacts of urbanization on water and habitat quality (Diamond and Serveiss 2001, p. 4716; Gangloff et al. 2009, p. 198; Cao et al. 2013, pp. 1212–1214; Gillis et al. 2017, pp. 674–679). The threats analysis in our SSA found the estimated probability of extirpation for all three species approaches 100 percent when developed land area is between 9 and 15 percent of the total land area in a watershed (Service 2020, p. 61). The term ''development'' refers to urbanization of the landscape, including (but not limited to) land conversion for residential, commercial, and industrial uses and the accompanying infrastructure. Urbanization effects may include alterations to water quality, water quantity, and instream and streamside habitat (Ren et al. 2003, p. 649; Wilson 2015, p. 424). The effects on habitat also include variability in streamflow, typically increasing the extent and volume of water entering a stream after a storm and decreasing the time it takes for the water to travel over the land before entering the stream (Giddings et al. 2009, p. 1). In urbanized environments, storm drains deliver large volumes of water to streams much faster than would naturally occur, often resulting in flooding and bank erosion that reshape the channel and cause substrate instability. Increased, high-velocity discharges can cause species living in streams (including mussels) to become stressed, displaced, or killed by fastmoving water and the debris and sediment carried in it. Once floodwaters recede, displaced individuals may be left stranded out of the water, and fine sediments transported to the stream settle on coarser substrates, which may damage or destroy areas of mussel habitat. During storm events, contaminants in urbanized environments (e.g., gasoline, oil drips, fertilizers) accumulated on impervious surfaces may be washed directly into streams (USFWS, 2023)

Stressor: Energy Development—Coal, Natural Gas, and Oil (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Extraction of coal, natural gas, and (to a lesser extent) oil is common in the Cumberland and Upper Tennessee River basins and has been associated with mussel declines in several watersheds (Layzer and Anderson 1992, entire; Warren and Haag 2005, entire; Johnson et al. 2014, p. 890; TDEC 2014, p. 62; Zipper et al. 2016, pp. 612–613; Ahlstedt et al. 2016, p. 13). Examples of energy development impacts in the range of the three mussels include high levels of copper, manganese, and zinc, metals that can be toxic to freshwater mussels, found in sediment samples from both the Clinch and Powell Rivers. Both rivers receive runoff from active, reclaimed, and abandoned coal mine sites. In Cumberland Basin streams, including Buck Creek, Horse Lick Creek, Little South Fork, and Rockcastle River, there was a clear correlation between surface mines, increased metal concentrations downstream, and the extirpation of some mussel

species (Layzer and Anderson 1992, pp. 91–96). In the upper Powell River, Virginia, coal mining has almost eliminated the mussel fauna; sediment pore water from the riverbed contains levels of contaminants potentially toxic to mussels, particularly selenium and copper (Timpano et al. 2023, p. 13). Natural gas and oil extraction is a threat to freshwater mussels in the Upper Tennessee Basin and Cumberland Basin. In addition to the general impacts of erosion and sedimentation from forest clearing for access roads and installing drill pads, spills from (brine) disposal ponds at gas wells or end-of-pipe discharges from brine treatment facilities can reduce freshwater mussel abundance and diversity, as well as increase mortality. These effects have been observed in the Allegheny River (Patnode et al. 2015, p. 55), a watershed outside the range of the three mussel species, but within the Ohio Basin, which contains the Tennessee River and Cumberland River (USFWS, 2023)

Stressor: Agriculture (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Throughout the range of the three mussel species and have impacted watersheds in the species' historical and current ranges. The advent of intensive row crop agriculture is a potential factor in freshwater mussel decline and species extirpation in the eastern United States (Peacock et al. 2005, p. 550). Nutrient enrichment from fertilized crops and livestock is a threat commonly associated with negative effects on aquatic biota and can increase ammonia concentrations, to which freshwater mussels are particularly sensitive. In addition, agricultural pesticides, including herbicides, fungicides, insecticides, and their surfactants and adjuvants, are highly toxic to juvenile and adult freshwater mussels (Bringolf et al. 2007, p. 2,092). Concentrations of these contaminants from fields or pastures may be at levels that can affect an entire population, especially given the highly fragmented distributions of the three mussel species. Agricultural land use has been associated with decreased freshwater mussel diversity, growth, and survival in North American streams. A temporal analysis of freshwater mussel populations in Iowa streams showed declines in mussel species richness, and local extirpations corresponded with agricultural intensity and forest clearing of the riparian zone (Poole and Downing 2004, pp. 121–124). In those Iowa streams, the segments with the highest substrate diversity exhibited the lowest declines in species richness, indicating homogenization of substrates from sedimentation is a freshwater mussel stressor. Further, species richness increased or was unchanged where agriculture was less than 25 percent of the land use. Another study, in Minnesota streams, revealed decreases in mussel abundance and richness corresponding with increases in agricultural land use (Hornbach et al. 2019, p. 1,833). In Kentucky, streams in proximity to row crop agriculture were associated with higher values of contaminants (pesticides and fertilizers), and growth of caged mussels in those streams was low in comparison with most other streams, where row crops were a minor land use (Haag et al. 2019, pp. 761–763). One of the streams in the study with high row crop land use was the Red River, in the historical range of the Cumberland moccasinshell and with one current low-condition population of the Tennessee clubshell. The abnormally low growth rates observed in the streams in proximity to high row crop land use usually presage early mortality observed in mussel hatchery settings (USFWS, 2023)

Stressor: Contaminants (USFWS, 2023)
Exposure:
Response:

Consequence:
Narrative: Three of the land uses identified as threats to the three mussel species (urban development, energy development, and agriculture) contribute contaminants to stream habitats, which can degrade water and substrate quality and adversely impact individuals and populations. Although chemical spills and other point sources of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result in part from the subtle, pervasive effects of chronic, low-level contamination (USFWS, 2023)

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2020. Species Status Assessment for Three Freshwater Mussels from the Tennessee and Cumberland River Basins (Medionidus conradicus, Pleurobema oviforme, and Pleuronaia barnesiana), Version 1.0. Asheville Ecological Services Field Office, Asheville, North Carolina. USFWS. 2023. FR Vol, 88, No. 161. Pages 57060-57077. Endangered and Threatened Wildlife and Plants

Endangered Species Status for Tennessee Clubshell, Tennessee Pigtoe, and Cumberland Moccasinshell.

USFWS. 2023. FR Vol, 88, No. 161. Pages 57060-57077. Endangered and Threatened Wildlife and Plants

SPECIES ACCOUNT: *Pleurobema perovatum* (Ovate clubshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 3/17/1993; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A small freshwater mussel or bivalve mollusk which attains a maximum adult size of 50 mm (2.0 in.) in length. The outer shell varies from yellow to dark brown. Occasionally, broad green rays may cover most of the umbo and posterior ridge. This species is small to medium-sized with a shell oval to elliptical in shape with nearly terminal, inflated umbos. The posterior ridge is well-developed, broadly rounded, and often concave. The posterior slope is produced well beyond the posterior ridge. Periostracum color varies from yellow to dark brown, and occasionally has broad green rays that may cover most of the umbo and posterior ridge. The nacre is white (USFWS, 2000).

Taxonomy

The taxonomy of Pleurobema perovatum can be confusing. Pleurobema hanleyanum and Pleurobema troschelianum are among those with which it is easily confused. A form called Pleurobema pinkstoni is found in Chewacla Creek, Tallapoosa River drainage in Macon County, Alabama, and may be a valid species (Doug Shelton, pers. obs. 1996). Due to the terminal umbos in some specimens, P. perovatum may be mistaken for young P. decisum. They may be distinguished from the latter by their thinner shells and gentle posterior slope (USFWS, 1993). (NatureServe, 2015)

Historical Range

The Historic range includes Tombigbee River and tributaries, Alabama, Mississippi; Black Warrior River and tributaries, Alabama; Alabama River, Alabama; Cahaba River and tributaries, Alabama; Chewacla, Uphapee and Opintlocco Creeks in the Tallapoosa River drainage, Alabama: Coosa River and tributaries, Alabama, Georgia, Tennessee. (USFWS, 2000)

Current Range

It is endemic to the Mobile Basin of Alabama and Mississippi; widespread in the Mobile Basin with the exception of the Coosa and Tallapoosa River drainages above the Fall Line (Williams et al., 2008). (NatureServe, 2015)

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the ovate clubshell (and other species), under the Endangered Species Act of 1973, as amended (Act) (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat for the ovate clubshell (Pleurobema perovatum) is designated in Units 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 18, 19, 21, 24, 25, and 26; in AL, GA, MS, and TN.

Unit 2. Bull Mountain Creek, Itawamba County, Mississippi. Unit 2 encompasses 34 km (21 mi) of the Bull Mountain Creek stream channel in Mississippi extending from Mississippi Highway 25, upstream to U.S. Highway 78, Itawamba County, Mississippi. Bull Mountain Creek supports the southern clubshell and Alabama moccasinshell (Jones and Majure, 1999). This unit is within the historic range of the orange-nacre mucket (records are from the early 1980's (MMNS mussel collections)) and the ovate clubshell.

Unit 3. Buttahatchee River and tributary, Lowndes/Monroe County, Mississippi; Lamar County, Alabama. Unit 3 encompasses 110 km (68 mi) of river and stream channel in Mississippi and Alabama, including 87 km (54 mi) of the Buttahatchee River, extending from its confluence with the impounded waters of Columbus Lake (Tombigbee River), Lowndes/Monroe County, Mississippi, upstream to the confluence of Beaver Creek, Lamar County, Alabama; and 23 km (14 mi) of Sipsey Creek, extending from its confluence with the Buttahatchee River, upstream to the Mississippi/Alabama State Line, Monroe County, Mississippi. The Buttahatchee River continues to support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 2001; Hartfield and Jones, 1989; Jones, 1991; McGregor, 2000). The current distribution of the Alabama moccasinshell also extends into its tributary Sipsey Creek (McGregor, 2000).

Unit 4. Luxapalila Creek and tributary, Lowndes County, Mississippi; Lamar County, Alabama. Unit 4 encompasses 29 km (18 mi) of stream channel, including 15 km (9 mi) of Luxapalila Creek, extending from Waterworks Road, Columbus, Mississippi, upstream to approximately 1.0 km (0.6 mi) above Steens Road, Lowndes County, Mississippi; and 15 km (9 mi) of Yellow Creek extending from its confluence with Luxapalila Creek, upstream to the confluence of Cut Bank Creek, Lamar County, Alabama. Luxapalila and Yellow Creeks support and provide habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Hartfield and Bowker, 1992; McGregor, 2000; Miller, 2000; Yokley 2001).

Unit 5. Coalfire Creek, Pickens County, Alabama. Unit 5 encompasses 32 km (20 mi) of the Coalfire Creek stream channel extending from its confluence with the impounded waters of Aliceville Lake (Tombigbee River), upstream to U.S. Highway 82, Pickens County, Alabama. Coalfire Creek supports the orange-nacre mucket and ovate clubshell (P. Hartfield, Service field records 1991; McGregor, 2000). The creek is in the historic range of the southern clubshell and Alabama moccasinshell.

Unit 6. Lubbub Creek, Pickens County, Alabama. Unit 6 encompasses 31 km (19 mi) of the Lubbub Creek stream channel extending from its confluence with the impounded waters of Gainesville Lake (Tombigbee River), upstream to the confluence of Little Lubbub Creek, Pickens County, Alabama. This stream supports the southern clubshell, orangenacre mucket, and Alabama moccasinshell (P. Hartfield, Service field records, 1991; McGregor, 2000; Pierson, 1991a). It is in the historic range of the ovate clubshell.

Unit 7. Sipsey River, Greene/Pickens, Tuscaloosa Counties, Alabama. Unit 7 encompasses 90 km (56 mi) of the Sipsey River channel from the confluence with the impounded waters of Gainesville Lake (Tombigbee River), Greene/Pickens County, upstream to Alabama Highway 171 crossing, Tuscaloosa County, Alabama. This small river supports and provides some of the best remaining habitat for the southern clubshell, orange-nacre mucket, ovate clubshell, and Alabama moccasinshell (Haag and Warren, 1997; McCullagh et al., 2002; McGregor, 2000; MMNS Mussel

Collection; Pierson, 1991 a, b).

Unit 8. Trussels Creek, Greene County, Alabama. Unit 8 encompasses 21 km (13 mi) of creek channel extending from its confluence with the impounded waters of Demopolis Lake (Tombigbee River), upstream to Alabama Highway 14, Greene County, Alabama. The orangenacre mucket continues to survive in Trussels Creek, and it is in the historic range of the ovate clubshell, Alabama moccasinshell, and southern clubshell (P. Hartfield field records, 1993; McGregor, 2000).

Unit 10. Sipsey Fork drainage, Winston, Lawrence Counties, Alabama. Unit 10 encompasses 147 km (91 mi) of stream channel in Alabama, including: Sipsey Fork, 31 km (19 mi), from section 11/12 line, T10S R8W, Winston County, upstream to the confluence of Hubbard Creek, Lawrence County, Alabama; Thompson Creek, 8 km (5 mi), from confluence with Hubbard Creek, upstream to section 2 line, T8S R9W, Lawrence County, Alabama; Brushy Creek, 35 km (22 mi), from the confluence of Glover Creek, Winston County, Alabama, upstream to section 9, T8S R7W, Lawrence County, Alabama; Capsey Creek, 15 km (9 mi), from confluence with Brushy Creek, Winston County, upstream to the confluence of Turkey Creek, Lawrence County, Alabama; Rush Creek, 10 km (6 mi), from confluence with Brushy Creek, upstream to Winston/Lawrence County Line, Winston County, Alabama; Brown Creek, 5 km (3 mi), from confluence with Rush Creek, Winston County, upstream to section 24 line, T8S R7W Lawrence County, Alabama; Beech Creek, 3 km (2 mi), from confluence with Brushy Creek, to confluence of East and West Forks, Winston County, Alabama; Caney Creek and North Fork Caney Creek, 13 km (8 mi), from confluence with Sipsey Fork, upstream to section 14 line, Winston County, Alabama; Borden Creek, 18 km (11 mi), from confluence with Sipsey Fork, Winston County, Alabama, upstream to the confluence of Montgomery Creek, Lawrence County, Alabama; Flannagin Creek, 10 km (6 mi), from confluence with Borden Creek, upstream to confluence of Dry Creek, Lawrence County, Alabama. The upper Sipsey Fork drainage currently supports the most robust and extensive populations of the dark pigtoe, orangenacre mucket, Alabama moccasinshell, and triangular kidneyshell (Haag and Warren, 1997; Haag et al., 1995; Hartfield, 1991; Hartfield and Butler, 1997; Hartfield and Hartfield, 1996; McGregor, 1992; Warren and Haag, 1994). Ovate clubshell have been reported from this drainage (Dodd et al., 1986).

Unit 11. North River and tributary, Tuscaloosa, Fayette Counties, Alabama. Unit 11 encompasses 47 km (29 mi) of river and stream channel in Alabama, including: North River, 42 km (26 mi) extending from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; Clear Creek, 5 km (3 mi), from its confluence with North River, to Bays Lake Dam, Fayette County, Alabama. Small numbers of the dark pigtoe and orange-nacre mucket continue to survive in the North River and Clear Creek (McGregor and Pierson, 1999; Pierson, 1992a; Vittor and Associates, 1993). This area is in the historic range of the Alabama moccasinshell, triangular kidneyshell, and ovate clubshell.

Unit 12. Locust Fork and tributary, Jefferson, Blount Counties, Alabama. Unit 12 encompasses 102 km (63 mi) of river and stream channel in Alabama, including: Locust Fork, 94 km (58 mi) extending from U.S. Highway 78, Jefferson County, upstream to the confluence of Little Warrior River, Blount County, Alabama; Little Warrior River, 8 km (5 mi), from its confluence with the Locust Fork, upstream to the confluence of Calvert Prong and Blackburn Fork, Blount County, Alabama. Scattered collections of the orange-nacre mucket and triangular kidneyshell suggest an enduring population of these species in the Locust Fork (P. Johnson pers. comm., 2002; Hartfield, 1991; Shepard et al., 1988). This stream is also in the historic range of the dark pigtoe, Alabama moccasinshell, ovate clubshell, and upland combshell.

Unit 13. Cahaba River and tributary, Jefferson, Shelby, Bibb Counties, Alabama. Unit 13 encompasses 124 km (77 mi) of river channel in Alabama, including: Cahaba River, 105 km (65 mi) extending from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; Little Cahaba River, 19 km (12 mi), from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama. Scattered individuals of triangular kidneyshell, orange-nacre mucket, and fine-lined pocketbook continue to be collected from the Cahaba drainage (R. Haddock, Cahaba River Society, pers. comm., 2002; McGregor et al., 2000; Shepard et al., 1994). The river is historic habitat for the Alabama moccasinshell, southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 17. Uphapee/Choctafaula/ Chewacla Creeks, Macon, Lee Counties, Alabama. Unit 17 encompasses 74 km (46 mi) of stream channel in Alabama, including: Uphapee Creek, 18 km (11 mi) of river channel extending from Alabama Highway 199, upstream to confluence of Opintlocco and Chewacla Creeks, Macon County, Alabama; Choctafaula Creek, 11 km (7 mi), from confluence with Uphapee Creek, upstream to Macon County Road 54, Macon County, Alabama; Chewacla Creek, 29 km (18 mi), from confluence with Opintlocco Creek, Macon County, Alabama, upstream to Lee County Road 159, Lee County, Alabama; Opintlocco Creek, 16 km (10 mi), from confluence with Chewacla Creek, upstream to Macon County Road 79, Macon County, Alabama. This stream network supports small and localized populations of the fine-lined pocketbook, ovate clubshell, and southern clubshell (M. Gangloff, Auburn University, in litt., 2001; Gangloff, 2002; McGregor, 1993; Pierson, 1991a).

Unit 19. Hatchet Creek, Coosa, Clay Counties, Alabama. Unit 19 encompasses 66 km (41 mi) of the Hatchet Creek channel in Alabama, extending from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama. The fine-lined pocketbook occurs within this reach (Feminella and Gangloff, 2000; Pierson, 1992b). Hatchet Creek is within the historic range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, southern clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 21. Kelly Creek and tributary, Shelby, St. Clair Counties, Alabama. Unit 21 encompasses 34 km (21 mi) of stream channel in Alabama, including: Kelly Creek, 26 km (16 mi) extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama; Shoal Creek, 8 km (5 mi), from confluence with Kelly Creek, St. Clair County, Alabama, upstream to St. Clair/ Shelby County Line, St. Clair County, Alabama. Kelly/Shoal Creeks continue to support scattered individuals of the fine-lined pocketbook, and the southern clubshell and triangular kidneyshell survive in Kelly Creek (Pierson pers. comm., 1995; Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream complex is historic habitat for the southern pigtoe, Coosa moccasinshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 24. Big Canoe Creek, St. Clair County, Alabama. Unit 24 encompasses 29 km (18 mi) of the Big Canoe Creek channel, extending from its confluence with Little Canoe Creek at the St. Clair/ Etowah County line, St. Clair County, upstream to the confluence of Fall Branch, St. Clair County, Alabama. The southern clubshell, southern pigtoe, and triangular kidneyshell are surviving in low numbers in Big Canoe Creek (Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream is also historic habitat for the fine-lined pocketbook, ovate clubshell, Coosa moccasinshell, upland combshell, and southern acornshell.

Unit 25. Oostanaula River/Coosawattee River/Conasauga River/Holly Creek, Floyd, Gordon, Whitfield, Murray Counties, Georgia; Bradley, Polk Counties, Tennessee. Unit 25 encompasses 206 km (128 mi) of river and stream channel in Georgia and Tennessee, including: Oostanaula River, 77 km (48 mi) extending from its confluence with the Etowah River, Floyd County, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; Coosawattee River, 15 km (9 mi), from confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; Conasauga River, 98 km (61 mi), from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to the Murray County Road 2, Murray County, Georgia; Holly Creek, 16 km (10 mi), from confluence with Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia. This extensive riverine reach continues to support small and localized populations of fine-lined pocketbook, southern pigtoe, triangular kidneyshell, Alabama moccasinshell, and Coosa moccasinshell. The triangular kidneyshell survives throughout this unit, while the fine-lined pocketbook, southern pigtoe, and Coosa moccasinshell appear to be currently restricted to the Conasauga River and Holly Creek and the southern clubshell appears restricted to a small 15 km (9 mi) reach of the Conasauga River (Evans, 2001; Johnson and Evans, 2000; Pierson in litt., 1993; Williams and Hughes, 1998). The Alabama moccasinshell is currently known to survive only in the Holly Creek portion of this Unit (Evans, 2001; Johnson and Evans, 2000). The Oostanaula/ Coosawattee/Conasauga Unit also contains historic habitat for the southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 26. Lower Coosa River, Elmore County, Alabama. Unit 26 encompasses 13 km (8 mi) of the Lower Coosa River channel, extending from Alabama State Highway 111 bridge, upstream to Jordan Dam, Elmore County, Alabama. This river reach is within the historic range of fine-lined pocketbook, southern clubshell, Alabama moccasinshell, Coosa moccasinshell, ovate clubshell, southern pigtoe, triangular kidneyshell, upland combshell, and southern acornshell. (Johnson, 2002; Pierson, 1991a).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the ovate clubshell (Pleurobema perovatum) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter he stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: All mussels are filter feeders. Oxygen-bearing water and food are drawn into the incurrent siphon, and waste-carrying water is simultaneously passed out the excurrent siphon. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS, 2000).

Reproduction Narrative

Adult: Gravid females have been observed in June and July (summer brooder unlike other Pleurobema). Glochidia are released in well formed white conglutinates. Host fishes are unknown (USFWS, 2003) (NatureServe, 2015). While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years (USFWS, 2000).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Fragmented (USFWS, 2008)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species occupies sand/gravel shoals and runs of small rivers and large streams (USFWS, 2000). Parmalee and Bogan (1998) list habitat in Tennessee as a sand and fine gravel substrate in stretches of river with moderate current and typically at a depth of less than three feet. The environmental specificity of this species is narrow and it is highly to moderately vulnerable. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). The range of this species is highly fragmented (USFWS, 2008).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Species Trends:

Unknown (USFWS, 2008)

Number of Populations:

5 - 7 (NatureServe 2015)

Population Size:

Unknown (NatureServe, 2015)

Adaptability:

Poor construction practices make this species vulnerable even on public lands. Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). (NatureServe, 2015)

Population Narrative:

Poor construction practices make this species vulnerable even on public lands. Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). As Pleurobema flavidulum: ANSP has one specimen from Coal Fire Creek, Pickens Co., Alabama, collected in 1933; FLMNH houses specimens collected at the turn of the Twentieth Century from Coalfire Creek and Lubbub Creek in Pickens Co., the Sipsey River in Fayette Co., and Euphapee Creek in Macon Co., Alabama. As Pleurobema johannis, this species was formerly distributed in the Coosa River system of Alabama (Mobile basin) and in Tennessee (Mirarchi et al., 2004); and in the Coosa River basin in Georgia, it was known historically from the Etowah and Conasauga River drainages prior to extirpation (Williams and Hughes, 1998) (type locality is given as the Conasauga and Etowah Rivers in Georgia- Simpson, 1914). This species has experienced a long-term decline of 50-70%. The range extent is 40 - 100 square miles, with extant occurrences at 5 - 7 sites. Only 1 - 3 of these occurrences has good viability/integrity (NatureServe, 2015). The status of this species is unknown, based on the 2007 Recovery Data Call (USFWS, 2008).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species. The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin. Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a mollusk-eating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: All populations of this species are affected by and susceptible to stochastic and chronic events (e.g., spills, drought and/or landuse runoff) (USFWS, 2008).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Recovery

Reclassification Criteria:
Reclassification is not a realistic goal for this species at this time (USFWS, 2000).

Delisting Criteria:
1. Six (6) populations exhibit a stable or increasing trend, natural recruitment, and multiple age classes. 2. At least one (1) population (as defined in criteria 1) occurs within each of the presently occupied sub-basins: (Alabama, Cahaba, Tallapoosa, and Tombigbee). 3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (USFWS, 2019)

Recovery Actions:
- Protect habitat integrity and quality ofriver and stream segments that currently support or could support imperiled aquatic species (USFWS, 2000).

- Consider options for free-flowingriver and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promotevoluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement programs and materials to educate the public on the need and benefits ofecosystem management, and toinvolve them in watershed stewardship (USFWS, 2000).
- Conduct basic research on endemic aquatic species and apply the results toward management and protection ofaquatic communities (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Develop measurable recovery criteria (USFWS, 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS, 2008).
- Develop and implement plan to describe and monitor habitat conditions where the species survives (USFWS, 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS, 2008).
- Work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson, Mississippi

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson, Mississippi.

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

USFWS. 2019. Recovery Plan Revision for the Endangered Ovate Clubshell (Pleurobema perovatum). Amendment 1.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Pleurobema plenum* (Rough pigtoe)

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 06/14/1976, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

A highly variable freshwater mussel; relatively large, rounded to slightly angular, or elongate, shaped like an equilateral triangle, with a brown satin-like appearance and a moderately deep beak cavity.The shell is somewhat triangular, more high than long, moderately thick, and inflated. Anterior and posterior ends rounded. Dorsal and ventral margins curved. Umbos inflated and elevated above the hinge line. Beak sculpture of two to three elevated ridges. Shell textured, with a satin-like appearance. Periostracum yellowish brown or light brown in small shells, becoming dark brown in adults, with faint green rays visible near the beaks in some shells. Length to four inches. Pseudocardinal teeth well developed; two in the left valve, one in the right. Lateral teeth straight. Beak cavity moderately deep. Nacre usually white, occasionally pink (Cummings and Mayer, 1992). (NatureServe, 2015)

Taxonomy

The members of the genus Pleurobema are among the most difficult to identify in North America. Arguments arise even among taxonomists regarding the "species" represented in the genus Pleurobema. Stansbery (1983) summarized many of the problems and identified a few of the shell characters used to separate Pleurobema sintoxia from the morphologically similar and often co-occurring Pleurobema plenum, Pleurobema cordatum, and Pleurobema rubrum. A few "morphs" have been variously identified and named but no rigorous genetic, anatomic, or conchologic study has ever been published on this group to help elucidate species boundaries or relationships. Species status of Pleurobema plenum is questionable. (NatureServe, 2015)

Historical Range

Historically, this species was widely distributed in the Ohio, Cumberland, and Tennessee river drainages (USFWS, 1984). Historical populations are gone in the upper Ohio River drainage and western parts of its range (Arkansas, Missouri, and Kansas) if in fact it ever occurred there. In Alabama, In Alabama, extant populations are in the Tennessee River tailwaters of Wilson Dam (very rare) and possibly Guntersville Dam (Mirarchi et al., 2004) but historically it is known from the following counties: Colbert, Lauderdale, Madison, Morgan, Marshall, Lawrence, Limestone. (NatureServe, 2015)

Current Range

Currently, it is present in an undetermined number of miles below three Tennessee River mainstem dams (Pickwick, Wilson, and Guntersville) and the upper Clinch River between river miles 323 and 154 (likely only extant and viable between rm 189 and 154) primarily on the Tennessee side at the Virginia border. Although reported by Parmalee et al. (1980) from the middle Cumberland River between 1977 and 1979, it was not found in recent surveys by Tennessee Valley Authority (1976) or Sickel and Chandler (1996). It is present on the Green River, Kentucky between locks 4 and 5 and in the Barren River (Green River tributary in Kentucky) below Lock and Dam 1 (USFWS, 1984). Clarke (1983) found a single living specimen in the Green River near Glenmore, Kentucky. (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Reproduction Narrative

Adult: The reproductive cycle of Pleurobema plenum is presumed to be similar to other Pleurobema spp. (Yokley, 1972). During spawning, males release sperm into the water column, and the sperm are taken in by the females during siphoning. Eggs are fertilized in the female's suprabranchial cavity or gills, which serve as marsupia for embryos developing to the parasitic stage (glochidia). Glochidia are released by the female and must attach to a suitable fish host for metamorphosis to the free-living juvenile stage. This species is probably a short-term breeder, based on gravid females collected in May (Ortmann, 1919). Spawning occurs in spring and glochidia are released in summer (USFWS, 1984). Glochidia are probably semicircular and hookless (Yokley, 1972; Surber, 1915). Fish hosts are unknown for this species.; (NatureServe, 2015)

Environmental Specificity

Adult: Narrow. Specialist or community with key requirements common. (Natureserve, 2015)

Habitat Narrative

Adult: This species is found in medium to large rivers (20 m wide or greater) in sand, gravel, and cobble substrates in shoals. It is occasionally found on flats and muddy sand (Gordon and Layzer, 1989; USFWS, 1984).BIG RIVER; MEDIUM RIVER; RiffleBenthic (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Dispersal

Adult: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Additional Life History Information

Adult: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Population Information and Trends

Adaptability:

Sensitive to pollution, siltation, habitat perturbation, inundation, commercial harvest, and loss of glochidial hosts. The species currently has a disjunct distribution from what was once a widespread distribution limiting dispersal and exchange of genetic material. (NatureServe, 2015)

Population Narrative:

Populations of the Rough Pigtoe currently exist in portions of the Clinch, Tennessee, Cumberland, Green, Barren, and Licking rivers. The species was observed in the East Fork White River in Indiana in 1992, but the species has not been observed there since that time. Currently, the Clinch (Tennessee) and Green (Kentucky) rivers represent the only populations with evidence of successful reproduction. Rough Pigtoe mussels typically do not exist in populations large enough to support translocation. However, recent host trials may provide hope that propagation can be successful in producing juvenile mussels for recovery actions (reintroductions at extirpated sites or augmentation of existing populations). As such, future reintroductions, augmentations, and translocations of individuals will likely be accomplished through introductions of captively-propagated juveniles. (USFWS, 2021)

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: Smith (1971) ranked the causes of extirpation or declines in fish species as follows: siltation, drainage of bottomland lakes, swamps, and prairie marshes, desiccation during drought, species introductions, pollution, impoundments, and increased water temperatures. All of these factors render habitats unsuitable, cause extirpations, and lead to the isolation of populations thereby increasing their vulnerability to extirpation for many aquatic species (including mussels) throughout North America. Zebra mussels, Dreissena polymorpha, have destroyed mussel populations in the Great Lakes and significantly reduced mussels in many of the large rivers of eastern North America. Zebra mussels have the potential to severely threaten other populations especially if they make their way into smaller streams. Pollution through point (industrial and residential discharge) and non-point (siltation, herbicide and fertilizer run-off) sources is perhaps the greatest on-going threat to this species and most freshwater mussels. Lowered dissolved oxygen content and elevated ammonia levels (frequently associated with agricultural runoff and sewage discharge) have been shown to be lethal to some species of freshwater naiads (Horne and McIntosh, 1979). Residential, mineral and industrial development also pose a significant threat. Rotenone, a toxin used to kill fish in bodies of water for increased sport fishery quality, has been shown to be lethal to mussels as well (Heard, 1970). Destruction of habitat through stream channelization and maintenance and the construction of dams is still a threat in some areas. Impoundments reduce currents that are necessary for basic physiological activities such as feeding, waste removal and reproduction. In addition, reduced water flow typically results in a reduction in water oxygen levels and a settling out of suspended solids (silt, etc.), both of which are detrimental. Dredging of streams has an immediate effect on existing populations by physically removing and destroying individuals. Dredging also affects the long-term recolonization abilities by destroying much of the potential habitat, making the substrates and flow rates uniform throughout the system. Natural predators include raccoons, otter, mink, muskrats, turtles and some birds (Simpson, 1899; Boepple and Coker, 1912; Evermann and Clark, 1918; Coker et al., 1921; Parmalee, 1967; Snyder and Snyder, 1969). Domestic animals such as hogs can root mussel beds to pieces (Meek and Clark, 1912). Fishes, particularly catfish, Ictalurus

spp. and Amieurus spp., and freshwater drum, Aplodinotus grunniens, also consume large numbers of unionids.The federal recovery plan (USFWS, 1984) lists the following threats: impoundment (for flood control, navigation, hydroelectric power, and recreation), siltation (due to strip mining, coal washing, dredging, farming, logging, and road construction), pollution (from municipal, agricultural, and industrial discharges). Invasion by zebra mussels is a recent threat to this species' survival. (NatureServe, 2015)

Recovery

Recovery Actions:

- Preserve populations and presently used habitat of P. plenum with major emphasis on the Tennessee, Clinch, Cumberland and Green Rivers. Determine the feasibility of introducing the species back into rivers within its historic range and introduce where feasible. Conduct life history studies not under the above sections. Determine the number of individuals required to maintain a viable population. Investigate the necessity for habitat improvement and, if feasible and desirable, identify techniques and sites for improvement to include implementation. Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations. Assess overall success of recovery programs and recommend action (delist, continued protection, implement new measures, other studies, etc.). (USFWS, 1984)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The following recovery actions should be undertaken to help achieve recovery for the species: 1) Continue life history studies and determine suitable hosts for captive propagation and culture techniques, including ‘in vitro’ transformation of the glochidia. 2) Develop a captive propagation/reintroduction plan for the species: a. Captive holding of Rough Pigtoe mussels may provide additional options for the species’ recovery and re-establishment into historic habitat. Captive husbandry methods should be developed. b. An assessment of historic habitat should be completed to identify sites where Rough Pigtoe mussel augmentation and re-establishment can be achieved. Restoration of these habitats should be made a priority to support this activity. c. Implement the plan by reintroducing the species into historic habitats and augmenting populations as appropriate. 3) Continue monitoring existing populations. More exhaustive surveys are needed in the Barren, Cumberland, and Licking rivers where information about the Rough Pigtoe is lacking. 4) Determine target population sizes for recovery of the species within its current range. 5) Determine sensitivity of each life stage for selected contaminants that are likely to be found in streams in which this species exists and at potential augmentation and reintroduction sites. 6) Through various means of land protection and restoration (land acquisition, best management practices (BMPs), conservation easements), abate non-point source impacts and direct habitat loss. (USFWS, 2021)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A." USFWS. 2021. Rough Pigtoe Pleurobema plenum 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Kentucky Ecological Services Field Office Frankfort, Kentucky. 26 pp.

USFWS. 1984. Recovery Plan for the Rough Pigtoe Pearly Mussel. Pleurobema plenum (Lea, 1840). 64 pp.

USFWS. 2021. Rough Pigtoe Pleurobema plenum 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Kentucky Ecological Services Field Office Frankfort, Kentucky. 26 pp.

SPECIES ACCOUNT: *Pleurobema pyriforme* (Oval pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/15/2007; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A small to medium-sized, suboviform, chestnut colored freshwater mussel. See Williams and Butler (in press). Shell is suboviform compressed, with a shiny smooth epidermis. The periostracum is yellowish, chestnut, or dark brown, rayless, and with distinct growth lines. Umbos are slightly elevated above the hingeline. No sexual dimorphism is displayed. Pseudocardinal teeth are fairly large, crenulate, and double in both valves. Lateral teeth are somewhat shortened, arcuate, and double in each valve. Nacre color varies from salmon to bluish white and is iridescent posteriorly (Butler and Alam, 1999). The length is 6 cm and the width is 3 cm. (NatureServe, 2015)

Taxonomy

Williams and Butler (in Deyrup and Franz, 1994) listed Pleurobema reclusum as a species distinct from Pleurobema pyriforme, but based on recent genetic data (Kandl et al., 1997) and morphological evidence (Clench and Turner, 1956) they are viewed as one species (Brim Box and Williams, 2000). (NatureServe, 2015)

Historical Range

Historically, this species occurred in the Ecofina, Apalachicola-Chattahoochee-Flint, Ochlockonee, and Suwanee systems in 57 localities (96 records) in Alabama, Georgia, and Florida (Brim Box and Williams, 2000). (NatureServe, 2015)

Current Range

The species exists in all four historical systems but subpopulations have been lost in the Apalachicola-Chattahoochee-Flint (Chattahoochee River main stem, Randall, Uchee, and Little Uchee Creek; most of Flint River main stem, Patsiliga, Little Patsiliga, Sandy Mount, Gum, Cedar, Chokee, Abrams, Mill, Little Pachitla, and Dry Creeks; Apalachicola River main stem; Spring, Rocky, Marshall, Big, and Cowarts Creeks), and it is nearly extirpated from Alabama (USFWS, 2003). In Alabama, it is confined to headwaters of Chipola River and lower Chattahoochee River system with one known extant population in Big Creek, a headwater tributary of Chipola River, Houston Co. (Mirarchi et al., 2004). (NatureServe, 2015)

Critical Habitat Designated

Yes; 11/15/2007.

Legal Description

On November 15, 2007, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the oval pigtoe (Pleurobema pyriforme) under the Endangered Species Act of 1973, as amended (72 FR 64286 - 64340).

Critical Habitat Designation

Critical habitat for the oval pigtoe (Pleurobema pyriforme) is designated in Units 1, 2, 4, 5, 6, 7, 9, and 11; in AL, FL, and GA.

Unit 1: Econfina Creek, Florida. Unit 1 includes the main stem of Econfina Creek and one of its tributaries in Bay and Washington counties, Florida, encompassing a total stream length of 31.4 km (19.5 mi). The main stem of Econfina Creek as designated extends from its confluence with Deer Point Lake at the powerline crossing located 3.8 km (2.3 miles) downstream of Bay County Highway 388, Bay County, Florida, upstream 28.6 km (17.8 mi) to Tenmile Creek in Washington County, Florida. Unit 1 also includes the tributary stream Moccasin Creek from its confluence with Econfina Creek upstream 2.8 km (1.7 mi) to Ellis Branch in Bay County. Unit 1 is designated for the Gulf moccasinshell and oval pigtoe (Blalock-Herod unpub. data 2002–03; Brim Box unpub. data 1996; Williams unpub. data 1993). PCEs in Unit 1 are vulnerable to impacts from sedimentation, urbanization, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 2: Chipola River, Alabama and Florida. Unit 2 includes the main stem of the Chipola River (including the reach known as Dead Lake) and six of its tributaries, encompassing a total stream length of 190.0 km (118.1 mi) in Houston County, Alabama; and in Calhoun, Gulf, and Jackson counties, Florida. The main stem of the Chipola River as designated extends from its confluence with the Apalachicola River in Gulf County, Florida, upstream 144.9 km (90.0 mi) to the confluence of Marshall and Cowarts creeks in Jackson County, Florida. A short segment of the Chipola River that flows underground within the boundaries of Florida Caverns State Park in Jackson County, Florida, is not included in Unit 2. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The tributaries of the Chipola River included in Unit 2 are: Dry Creek, from the Chipola River upstream 7.6 km (4.7 mi) to Ditch Branch in Jackson County, Florida; Rocky Creek, from the Chipola River upstream 7.1 km (4.4 mi) to Little Rocky Creek in Jackson County, Florida; Waddells Mill Creek, from the Chipola River upstream 3.7 km (2.3 mi) to Russ Mill Creek in Jackson County, Florida; Baker Creek, from Waddells Mill Creek upstream 5.3 km (3.3 mi) to the confluence with Tanner Springs in Jackson County, Florida; Marshall Creek, from the Chipola River upstream 13.7 km (8.5 mi) to the Alabama-Florida State line in Jackson County, Florida (this creek is known as Big Creek in Alabama); Big Creek, from the AlabamaFlorida State line upstream 13.0 river km (8.1 river mi) to Limestone Creek, in Houston County, Alabama; and Cowarts Creek from the Chipola River in Jackson County, Florida, upstream 33.5 river km (20.8 river mi) to the Edgar Smith Road bridge, in Houston County, Alabama. This unit is designated for the fat threeridge (Brim Box and Williams 2000, p. 92–93; Miller 1998, p. 54), shinyrayed pocketbook (Williams unpub. data 2002; Brim Box and Williams 2000, p. 109–110; Smith unpub. data 2001; Blalock-Herod unpub. data 2000, 2003; Butler unpub. data 1993, 1994, 1999, 2000); Gulf moccasinshell (Butler unpub. data 1999, 2002; Brim Box and Williams 2000, p. 113–114; D.N. Shelton pers. comm. 1998); oval pigtoe (Butler unpub. data 1993, 1999, 2002; Brim Box and Williams 2000, p. 116–117; Williams unpub. data 2000); and Chipola slabshell (Butler unpub. data 1993, 2000; Brim Box and Williams 2000, p. 95–96). PCEs in Unit 2 are vulnerable to impacts from sedimentation, urbanization, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 4: Sawhatchee Creek and Kirkland Creek, Georgia. Unit 4 includes the main stems of Sawhatchee Creek and Kirkland Creek and one tributary of Sawhatchee Creek, encompassing a total stream length of 37.8 km (23.5 mi) in Early County, GA. The main stem of Sawhatchee Creek as designated extends from its confluence with the Chattahoochee River upstream 28.6 km (17.8 mi) to the powerline crossing located 1.4 km (0.87 mi) upstream of County Road 15, Early County, GA. The main stem of Kirkland Creek extends from its confluence with the Chattahoochee River upstream 6.1 km (3.8 mi) to Dry Creek, Early County, GA. The tributary, Sheffield Mill Creek, is included from its confluence with Sawhatchee Creek upstream 3.1 km (1.9 mi) to the powerline crossing located 2.3 km (1.4 mi) upstream of Sowhatchee Road, Early County, GA. Unit 4 is designated for the shinyrayed pocketbook, Gulf moccasinshell, and oval pigtoe (Brim Box and Williams 2000, p. 109–110, 113–114, 116–117; Abbott pers. comm. 2005; Stringfellow pers. comm. 2003). PCEs in Unit 4 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 5: Upper Flint River, Georgia. Unit 5 includes the main stem of the Flint River and eight of its tributaries upstream of Lake Blackshear, plus two tributaries that flow into Lake Blackshear, encompassing a total stream length of 380.4 km (236.4 mi) in Coweta, Crawford, Crisp, Dooly, Fayette, Macon, Meriwether, Peach, Pike, Spalding, Sumter, Talbot, Taylor, Upson, and Worth counties, Georgia. The main stem of the Flint River in designated Unit 5 extends from the State Highway 27 bridge (Vienna Road) in Dooly and Sumter counties, Georgia (the river is the county boundary), upstream 247.4 km (153.7 mi) to Horton Creek in Fayette and Spalding counties, Georgia (the river is the county boundary). The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributary streams in Unit 5 are: Swift Creek, from Lake Blackshear upstream 11.3 km (7 mi) to Rattlesnake Branch in Crisp and Worth counties, Georgia (the creek is the county boundary); Limestone Creek, from Lake Blackshear in Crisp County, Georgia, upstream 8.8 km (5.5 mi) to County Road 89 in Dooly County, Georgia; Turkey Creek, from the Flint River upstream 21.7 km (13.5 mi) to Rogers Branch in Dooly County, Georgia; Pennahatchee Creek, from Turkey Creek upstream 4.8 km (3 mi) to Little Pennahatchee Creek in Dooly County, Georgia; Little Pennahatchee Creek, from Pennahatchee Creek upstream 5.8 km (3.6 mi) to Rock Hill Creek in Dooly County, Georgia; Hogcrawl Creek, from the Flint River upstream 21.6 km (13.4 mi) to Little Creek in Dooly and Macon counties, Georgia (the creek is the county boundary); Red Oak Creek, from the Flint River upstream 21.7 km (13.5 mi) to Brittens Creek in Meriwether County, Georgia; Line Creek, from the Flint River upstream 15.8 km (9.8 mi) to Whitewater Creek in Coweta and Fayette counties, Georgia (the creek is the county boundary); and Whitewater Creek, from Line Creek upstream 21.5 km (13.4 mi) to Ginger Cake Creek in Fayette County, Georgia. Unit 5 is designated for the shinyrayed pocketbook (Dinkins pers. comm. 1999, 2003; P.D. Johnson pers. comm. 2003; Brim Box and Williams 2000, p. 109–110; Roe 2000; L. Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); Gulf moccasinshell (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002; Brim Box and Williams 2000, p. 113–114; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997; Butler and Brim Box 1995, p. 3); oval pigtoe (Edwards Pittman Environmental 2004; McCafferty pers. comm. 2003; Dinkins pers. comm. 2002, 2003; Stringfellow pers. comm. 2000, 2003; Abbott pers. comm. 2001; Brim Box and Williams 2000, p. 116–117; Andrews pers. comm. 2000; Blalock-Herod unpub. data 1997); and purple bankclimber (Winterringer CCR pers. comm. 2003; Dinkins pers. comm. 2003; P.D. Johnson pers. comm. 2003; Albanese pers. comm. 2003 regarding unpub. data from De Genachete and CCR; Brim Box and Williams 2000, p. 105–106; E. Van De Genachete pers. comm. 1999). PCEs in Unit 5 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 6: Middle Flint River, Georgia. Unit 6 includes the main stem of the Flint River between Lake Worth (impounded by the Flint River Dam near Albany) and the Warwick Dam (which impounds

Lake Blackshear), and nine tributaries, encompassing a total stream length of 302.3 km (187.8 mi) in Dougherty, Lee, Marion, Schley, Sumter, Terrell, Webster, and Worth counties, Georgia. The main stem of the Flint River in Unit 6 extends from Piney Woods Creek in Dougherty County, Georgia (the approximate upstream extent of Lake Worth), upstream 39.9 km (24.8 mi) to the Warwick Dam in Lee and Worth counties, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Middle Flint River in Unit 6 are: Kinchafoonee Creek, from the LeeDougherty county line (the approximate upstream extent of Lake Worth) upstream 107.6 km (66.8 mi) to Dry Creek in Webster County, Georgia; Lanahassee Creek, from Kinchafoonee Creek upstream 9.3 km (5.8 mi) to West Fork Lanahassee Creek in Webster County, Georgia; Muckalee Creek, from the Lee-Dougherty county line (the approximate upstream extent of Lake Worth) upstream 104.5 km (64.9 mi) to County Road 114 in Marion County, Georgia; Little Muckalee Creek, from Muckalee Creek in Sumter County, Georgia, upstream 7.2 km (4.5 mi) to Galey Creek in Schley County, Georgia; Mill Creek, from the Flint River upstream 3.2 km (2 mi) to Mercer Millpond Creek in Worth County, Georgia; Mercer Millpond Creek, from Mill Creek upstream 0.45 km (0.28 mi) to Mercer Millpond in Worth County, Georgia; Abrams Creek, from the Flint River upstream 15.9 km (9.9 mi) to County Road 123 in Worth County, Georgia; Jones Creek, from the Flint River upstream 3.8 km (2.4 mi) to County Road 123 in Worth County, Georgia; and Chokee Creek, from the Flint River upstream 10.5 km (6.5 mi) to Dry Branch Creek in Lee County, Georgia. Unit 6 is designated for the shinyrayed pocketbook (Crow CCR pers. comm. 2004; Edwards Pittman Environmental 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; McCafferty pers. comm. 2000, 2001; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; BlalockHerod unpub. data 1997; Dinkins pers. comm. 1995; Brim Box and Williams 2000, p. 109–110), Gulf moccasinshell (Wisnewski unpub. data 2005; DeGarmo unpub. data 2002; Albanese pers. comm. 2003 regarding unpub. data from D. Shelton; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113– 114; Weston 1995), oval pigtoe (Wisnewski unpub. data 2005; Crow CCR pers. comm. 2004; Albanese pers. comm. 2003 regarding unpub. data from CCR; DeGarmo unpub. data 2002; Stringfellow unpub. data 2002; Golladay unpub. data 2001, 2002; Brim Box and Williams 2000, p. 116–117; P. Johnson unpub. data 1999; Blalock-Herod unpub. data 1997; Weston 1995), and purple bankclimber (Tarbell 2004; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 6 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 7: Lower Flint River, Georgia. Unit 7 includes the main stem of the Flint River between Lake Seminole (impounded by the Jim Woodruff Lock and Dam) and the Flint River Dam (which impounds Lake Worth), and nine tributaries, encompassing a total stream length of 396.7 km (246.5 mi) in Baker, Calhoun, Decatur, Dougherty, Early, Miller, Mitchell, and Terrell counties, GA. The main stem of the Flint River in Unit 7 extends from its confluence with Big Slough in Decatur County, GA (the approximate upstream extent of Lake Seminole) upstream 116.4 km (72.3 mi) to the Flint River Dam in Dougherty County, GA. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The nine tributaries of the Lower Flint River in Unit 7 are: Spring Creek, from Smith Landing in Decatur County, Georgia (the approximate upstream extent of Lake Seminole), upstream 74.2 km (46.1 mi) to County Road 35 in Early County, Georgia; Aycocks Creek, from Spring Creek upstream 15.9 km (9.9 mi) to Cypress Creek in Miller County, Georgia; Dry Creek, from Spring Creek upstream 9.9 km (6.1 mi) to Wamble Creek in Early County, Georgia; Ichawaynochaway Creek, from the Flint River in Baker County, Georgia, upstream 68.6 km (42.6

mi) to Merrett Creek in Calhoun County, Georgia; Mill Creek, from Ichawaynochaway Creek upstream 7.4 km (4.6 mi) to County Road 163 in Baker County, Georgia; Pachitla Creek, from Ichawaynochaway Creek upstream 18.9 km (11.8 mi) to Little Pachitla Creek in Calhoun County, Georgia; Little Pachitla Creek, from Pachitla Creek upstream 5.8 km (3.6 mi) to Bear Branch in Calhoun County, Georgia; Chickasawhatchee Creek, from Ichawaynochaway Creek in Baker County, GA, upstream 64.5 km (40.1 mi) to U.S. Highway 82 in Terrell County, Georgia; and Cooleewahee Creek, from the Flint River upstream 15.1 km (9.4 mi) to Piney Woods Branch in Baker County, Georgia. Unit 7 is designated for the shinyrayed pocketbook (Gangloff 2005; McCafferty pers. comm. 2004; Stringfellow unpub. data 2003; Dinkins pers. comm. 2001, 2003; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Albanese pers. comm. 2003 regarding unpub. data from CCR; Andrews pers. comm. 2000; BlalockHerod unpub. data 1997; Brim Box and Williams 2000, p. 109–110; Butler unpub. data 1993), Gulf moccasinshell (Abbott pers. comm. 2005; Golladay unpub. data 2001, 2002; P. Johnson unpub. data 1999; Brim Box and Williams 2000, p. 113–114; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), oval pigtoe (Dinkins pers. comm. 2001; Golladay unpub. data 2001, 2002; Andrews pers. comm. 2000; Brim Box and Williams 2000, p. 116– 117; P. Johnson unpub. data 1999; Butler unpub. data 1998; Blalock-Herod unpub. data 1997), and purple bankclimber (S. Carlson unpub. data 2002; Brim Box and Williams 2000, p. 105–106). PCEs in Unit 7 are vulnerable to impacts from sedimentation, urbanization, hydrologic alteration, and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 9: Upper Ochlockonee River, Florida, Georgia. Unit 9 includes the main stem of the Ochlockonee River upstream of Lake Talquin (impounded by the Jackson Bluff Dam) and three tributaries, encompassing a total stream length of 177.3 km (110.2 mi) in Gadsden and Leon counties, Florida, and Grady and Thomas counties, Georgia. The main stem of the Ochlockonee River in Unit 9 extends from its confluence with Gulley Branch (the approximate upstream extent of Lake Talquin) in Gadsden and Leon counties, Florida (the river is the county boundary), upstream to Bee Line Road/County Road 306 in Thomas County, Georgia. The downstream extent of each tributary within the unit is its mouth (its confluence with the water body named), and the upstream extent is the landmark listed. The three tributary streams in Unit 9 are: Barnetts Creek, from the Ochlockonee River upstream 20 km (12.4 mi) to Grady County Road 170/Thomas County Road 74 in Grady and Thomas counties, Georgia (the creek is the county boundary); West Barnetts Creek, from Barnetts Creek upstream 10 km (6.2 mi) to GA Highway 111 in Grady County, Georgia; and Little Ochlockonee River, from the Ochlockonee River upstream 13.3 km (8.3 mi) to Roup Road/County Road 33 in Thomas County, Georgia. Unit 9 is designated for the shinyrayed pocketbook (Blalock-Herod 2003, p. 1; McCafferty pers. comm. 2003; Williams unpub. data 1993), Ochlockonee moccasinshell (Brim Box and Williams 2000, p. 60; Williams and Butler 1994, p. 64), oval pigtoe (Edwards Pittman Environmental 2004; Blalock-Herod unpub. data 2003; Blalock-Herod 2003, p. 1; Williams unpub. data 1993), and purple bankclimber (Blalock-Herod unpub. data 2003; Blalock-Herod 2002, p. 1; Smith FDOT unpub. data 2001; Williams unpub. data 1993). PCEs in Unit 9 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Unit 11: Santa Fe River and New River, Florida. Unit 11 includes the main stem of the Santa Fe River and its tributary the New River, encompassing a total stream length of 83.1 km (51.6 mi) in Alachua, Bradford, Columbia, and Union counties, Florida. The main stem of the Santa Fe River as designated extends from where the river goes underground in O’Leno State Park in Alachua and Columbia counties, Florida (the river is the county boundary) upstream 60.2 km (37.4 mi) to the powerline crossing located 1.9 km (1.2 mi) downstream of U.S. Highway 301 in Alachua and Bradford counties, Florida (the river is the county boundary). The New River in Unit 11 extends from its confluence with the Santa Fe River at the junction of Alachua, Bradford, and Union counties, Florida, upstream 22.9 km (14.2 mi) to McKinney Branch in Bradford and Union counties, Florida (the river is the county boundary). Unit 11 is designated for the oval pigtoe (Blalock-Herod and Williams 2001, p. 5; Blalock-Herod 2000, p. 1–72; Williams unpub. data 1993, 1996–98). PCEs in Unit 11 are vulnerable to impacts from sedimentation and pollution, as described under ‘‘Special Management Considerations or Protections.’’

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements of critical habitat are:

(i) A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without a consistent aggrading or degrading bed elevation);

(ii) A predominantly sand, gravel, and/or cobble stream substrate with low to moderate amounts of silt and clay;

(iii) Permanently flowing water;

(iv) Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceeds the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251–1387); and

(v) Fish hosts (such as largemouth bass, sailfin shiner, brown darter) that support the larval life stages of the seven mussels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, airports, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on the effective date of this rule and not containing one or more of the primary constituent elements.

Activities in or adjacent to each of the critical habitat units described in this rule may affect one or more of the PCEs that are found in the unit. The features essential to each of the seven mussel species contained within the areas of this designation may require special management considerations or protections due to known or probable threats from these activities.

Management considerations to deal with sedimentation include protecting streams from sedimentation through application of agricultural and forestry best management practices, avoiding soiland vegetation-disturbing activity in the riparian zone, restoring unstable stream channels and other erosive areas, and other practices that prevent or reduce erosion.

Management considerations to deal with the threat of channel instability include avoiding soil- and vegetation-disturbing activity in the riparian zone, limiting impervious surface area, and other urban storm water runoff control methods. Sand and gravel mining (unit 3), dredging and channelization (unit 8), and dam construction (unit 5) may also affect channel stability.

Measures to deal with construction and operation of dams, water withdrawals, and water diversions include water conservation and operational strategies that manage water storage capacity and water demands in combination to minimize departures from the natural flow regime.

Management considerations to deal with the threat of pollution include applying agricultural and forestry best management practices, preserving native vegetation in riparian zones, maintaining septic systems, and taking other measures to minimize pollutantladen runoff to streams.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species (NatureServe, 2015). Adult freshwater mussels are filter-feeders. Based on the findings of studies such as Baldwin and Newell (1991) and Neves et al. (1996), an omnivorous opportunistic diet would allow mussels to take advantage of whatever food type happens to be abundant. Juvenile mussels employ foot (pedal) feeding, and are thus suspension feeders (Yeager et al. 1994) (USFWS, 2003).

Reproduction Narrative

Adult: Individuals are gravid from ACF basin from March through July at 55.4 to 77.0F. This indicates the species is a summer releasing species, but not necessarily a parent overwinterer, as fertilization may take place in late winter or early spring. Once released, glochidia remained viable for three days. Juveniles transformed on gills of Pteronotropis hypselopterus (sailfin shiner), Gambusia holbrooki (eastern mosquitofish), and Poecilia reticulata (guppy). Glochidia metamorphosed in 20 to 25 days at 70.7F (Butler and Alam, 1999; O'Brien and Williams, 2002) (NatureServe, 2015). O'Brien and Williams (2002) considered only the sailfin shiner as a primary host, as it was the only species upon which the transformation rate exceeded 50 percent (USFWS, 2007). No age specific information is available for this species, however closely related species are known to live 24 - 56 years (Moyer and Neves 1984). Glochidia may number in the tens of thousands to several million (Surber 1912, Coker et al. 1921, Yeager and Neves 1986). Species in the subfamily Ambleminae are generally tachytictic (USFWS, 2003).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Very narrow - moderate (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low - moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Dependency on Other Individuals or Species for Habitat

Adult: Silty sand to sand and gravel substrates (NatureServe, 2015)

Habitat Narrative

Adult: This species "Occurs in medium-sized creeks to small rivers where it inhabits silty sand to sand and gravel substrates, usually in slow to moderate current. Stream channels with clean substrates possibly offer the best habitat" (Williams and Butler, 1994, USFWS, 2003). The environmental specificity of this species is very narrow to moderate and it is highly to moderately vulnerable. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate although some passive movement downstream may occur during high flows. Dispersal occurs while the glochidia are encysted on their host (probably a fish). This species is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Species Trends:

Declining (USFWS, 2007) Resiliency (as defined in Smith et al. 2018) is met through Criterion 1 listed above. The Service believes that with data reflecting a stable or increasing trend in population numbers, and by demonstrating successful recruitment through multiple age classes, the populations will withstand regular stochastic events that may occur into the future (USFWS, 2019).

Number of Populations:

21 - 80 (NatureServe, 2015)

Population Size:

1000 - 2500 individuals (NatureServe, 2015)

Population Narrative:

The oval pigtoe is a wide-ranging species (1,412 rm in 11 watersheds) that has lost 73 percent of its historic extent of occurrence, but still persists in 386 rm of several watersheds. One entire basin of the oval pigtoe's distribution, the Suwannee River, is disjunct from the rest, and may represent genetic differences at the species level (USFWS, 2003). In Alabama it was confined to the Chattahoochee River drainage, above and below the Fall line, and headwaters of the Chipola River but only remains in two or three creeks in the Chipola drainage (Williams et al., 2008). This species has experienced a long-term decline of 50-70%. The range extent is 400 - 2,000 square miles, with a population size of 1,000 - 10,000 individuals. There are 21 - 80 occurrences with 1 - 12 occurrences having good viability/integrity (NatureServe, 2015). The species status is declining, based on a 2006 Recovery Data call (USFWS, 2007).

Threats and Stressors

Stressor: Harvest (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Occasional harvest of Apalachicolan Region species for commercial purposes has been documented in the past (Service 1994) (USFWS, 2003).

Stressor: Habitat alteration (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Sedimentation has been implicated as the principal cause of water quality impairment in the U.S. (EPA 1990). Specific biological impacts on mussels from excessive sediments include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, increased substrata instability, limited burrowing activity, and physical smothering (Ellis 1936, Stansbery 1971, Markings and Bills 1979, Kat 1982, Vannote and Minshall 1982, Aldridge et al. 1987, Waters 1995). Instream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, Yokley and Gooch 1976, Grace and Buchanan 1981, Hartfield and Ebert 1986, Schuster et al. 1989, Hartfield 1993, Howard 1997). Negative impacts include riparian forest clearing (e.g., mine site establishment, access roads, lowered floodplain water table); stream channel modifications (e.g., geomorphic instability, altered habitat, disrupted flow patterns including lowered elevation of stream flow, sediment transport); water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature); macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation); and changes in fish populations. Channelization affects a stream’s physical (e.g., erosion rates, depth, habitat diversity, geomorphic stability, riparian canopy) and biological (e.g., species composition and abundance, biomass, growth rates) characteristics (Stansbery and Stein 1971, Hartfield 1993, Hubbard et al. 1993). Channel construction for

navigation has been shown to increase flood heights (Belt 1975), which exacerbates the impacts of flood events that convey large quantities of sediments and contaminants in streams. Impoundments result in the elimination of riffle and shoal habitats and subsequent loss of mussel resources (van der Schalie 1938; Scruggs 1960; Neel 1963; Stansbery 1970, 1973; Schmidt et al. 1989; Williams et al. 1992; Layzer et al. 1993; Parmalee and Hughes 1993; Lydeard and Mayden 1995; Sickel and Chandler 1996; Watters 1996). By stalling water that would otherwise move, impoundments disrupt the many ecological processes driven by the variable flow of water, sediment, nutrient, and energy, as well as, increasing depth and sediment deposition (Williams et al. 1992, Ligon et al. 1995, Sparks 1995) (USFWS, 2003).

Stressor: Pollution (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Contaminants contained in point and non-point discharges can degrade water and substrate quality and adversely impact if not destroy mussel populations (Horne and McIntosh 1979, Neves and Zale 1982, McCann and Neves 1992, Havlik and Marking 1987). Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987) (USFWS, 2003).

Stressor: Urbanization (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Developmental activities associated with urbanization (e.g., highways, building construction, infrastructure creation, recreational facilities) may contribute significant amounts of sediment and other pollutants in quantities that may be detrimental to stream habitats (Waters 1995, Couch and Hamilton 2002). Urban development changes sediment regimes by creating impervious surfaces and drainage system installations (Brim Box and Mossa 1999) (USFWS, 2003).

Stressor: Logging (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: "Deadhead logging" causes disruption of habitat and increased sediment. The removal of deadhead logs may result in localized damage to mussels by resuspending fines and disrupting stable substrates associated with partially buried logs (USFWS, 2003).

Stressor: Water withdrawals (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Water quantity is becoming more of a concern in maintaining mussel habitat in the Apalachicolan Region. Extensive agricultural cropland areas, primarily planted in cotton, peanuts, corn, and soybeans, rely heavily on irrigation using groundwater, particularly in the Dougherty Plain. Pumping of groundwater from the Floridan Aquifer is contributing to decreased spring outflows and lowered stream levels (USFWS, 2003).

Stressor: Introduced species (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: Yeager et al. (2000) determined that high densities of Asian clams negatively impacted survival and growth of newly metamorphosed juvenile mussels and thus reduced recruitment. Zebra mussels in the Great Lakes have attached in large numbers (up to 10,000 per unionid) to the shells of live native mussels (Schloesser and Kovalak 1991), and have been implicated in the loss of mussel beds (Hunter and Bailey 1992, Masteller et al. 1993, Schloesser and Nalepa 1995). One of several Asian carp species intentionally brought to the U.S., black carp are known to eat clams (Corbicula spp.) and unionid mussels in China in addition to snails (USFWS, 2003).

Recovery

Reclassification Criteria:
1. The species has shown an increase in its current range to reflect occupation of at least 50 percent of its historic range (USFWS, 2007).

2. The species has at least three viable subpopulations in each of the watersheds that currently support it (USFWS, 2007).

3. The species has at least ten viable subpopulations in the large river basins within the historic range of the species for at least 3 generations (USFWS, 2007).

Delisting Criteria:
Biennial monitoring shows that an increase in the current number of subpopulaion/sites and extent of occurrence is enough to ensure population viability, reduce isolation among populations, and increase the potential for genetic exchange. Specific increases in subpopulations and river miles needed are currently unknown and will be determined by completing Recovery Tasks 1.3.6, 1.3.7, and 1.3.8 (USFWS, 2007).

1. Populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes. 1a) At least nine (9) populations exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (USFWS, 2019).

2. The spatial distribution of populations (as described in Criterion 1) are sufficient to protect against extinction from catastrophic events and maintain adaptive potential. 2a) At least one (1) population in each of the Econfina Creek, Chipola, Chattahoochee, Flint, Ochlockonee, Santa Fe, and Suwannee River systems, and two populations being located within the major tributary sub-basins of the Flint River (USFWS, 2019).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future.

Recovery Actions:
- Secure extant subpopulations and currently occupied habitats and ensure subpopulation viability (USFWS, 2003)

- Search for additional subpopulations of the species and suitable habitat (USFWS, 2003)
- Determine through research and propagation technology the feasibility of augmenting extant subpopulations and reintroducing or reestablishing the species into historical habitat (USFWS, 2003).
- Develop and implement a program to evaluate efforts and monitor subpopulation levels and habitat conditions of existing subpopulations, as well as newly discovered, reintroduced, or expanding subpopulations (USFWS, 2003).
- Develop and utilize a public outreach and environmental education program (USFWS, 2003).
- Assess the overall success of the recovery program and recommend actions (USFWS, 2003).
- The subpopulation recovery criteria defining a subpopulation as a site is vague and less meaningful than actual density or population estimates. As USFWS acquires more information about population characteristic, USFWS should revise recovery criteria. The USFWS recommends using quantitative methods to monitor changes in population size with each sub-basin (USFWS 2007).
- Define "viable subpopulation" through implementation of Recovery Tasks 1.3.6, 1.3.7, and 1.3.8 (USFWS 2007).
- Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders (USFWS 2007).
- Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies (USFWS 2007).
- Work with the EPA and States to modify numerical water quality criteria for ammonia and copper (USFWS 2007).
- Develop and implement a program to monitor subpopulation levels and habitat conditions of existing subpopulations (USFWS 2007).
- Continue re-evaluating threats to these mussels (USFWS 2007).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Assess the effects of Hurricane Michael damage on the affected sub-basins, especially the small stream populations in Econfina and Spring Creeks. 2. Reduce/prevent threats to existing populations and their habitats through habitat restoration programs and partnerships with various stakeholders. 3. Develop and adopt environmental flow criteria needed to maintain populations. 4. Complete genetic analysis to determine adaptive capacity. 5. Complete a detailed threats analysis for this species. 6. Incorporate detection analysis, occupancy modeling, and collection of size class data into monitoring efforts where possible. 7. Continue to work with State and Federal partners to incorporate conservation approaches into flow requirements and water allocation strategies. 8. Identify and survey poorly explored suitable habitat in currently and historically occupied sub-basins where the species may be present in low numbers or where re-introduction may be feasible. (USFWS, 2020)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 5, 2016.

U.S. Fish and Wildlife Service. 2007. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Final rule. 72 FR 64286 - 64340 (November 15, 2007).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

U.S. Fish and Wildlife Service. 2003. Recovery Plan for Endangered Fat Threeridge (Amblema neislerii), Shinyrayed Pocketbook (Lampsilis subangulata), Gulf Moccasinshell (Medionidus penicillatus), Ochlockonee Moccasinshell (Medionidus simpsonianus), and Oval Pigtoe (Pleurobema pyriforme)

and Threatened Chipola Slabshell (Elliptio chipolaensis), and Purple Bankclimber (Elliptoideus sloatianus). Atlanta, Georgia. 142 pp.

USFWS 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida. U.S. Fish and Wildlife Service. 2019 Amendment 1 to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Gulf Moccasinshell (Medionidus penicillatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elliploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata).

USFWS 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office Panama City, Florida

U.S. Fish and Wildlife Service. 2019 Amendment 1 to the U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Gulf Moccasinshell (Medionidus penicillatus), Oval Pigtoe (Pleurobema pyriforme), Purple Bankclimber (Elliploideus sloatianus), and Shinyrayed Pocketbook (Hamiota subangulata).

USFWS 2007. Fat Threeridge (Amblema neislerii) Shinrayed Pocketbook (Lampsilis subangulata) Gulf Moccasinshell (Medionidus simpsonianus) Oval Pigtoe (Pleurobema pyriforme) Chipola Slabshell (Elliptio chipolaensis) Purple Bankclimber (Elliptoideus sloatianus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office, Panama City, Florida.

USFWS. 2020. Draft. Oval Pigtoe (Pleurobema pyriforme) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Panama City Ecological Services Field Office Panama City, Florida. 27 pp.

SPECIES ACCOUNT: *Pleurobema riddellii* (Louisiana Pigtoe)

Species Taxonomic and Listing Information

Listing Status: Proposed Threatened

Physical Description

The Louisiana pigtoe is a rare freshwater mussel with a thick, inflated, triangular to sub-quadrate shell. The beaks are elevated well above the hinge line but are sometimes eroded. The external shell is without sculpturing and reddish-brown, dark brown, or black in color. The interior shell surface (nacre) is typically white, rarely peach tinted, and iridescent posteriorly. Pseudocardinal teeth (molar-like structures located near the beaks on the interior surface) are heavy to massive, triangular and rough with the anterior tooth in the left valve compressed and parallel to the margin. The lateral teeth, two in the left valve and one with a basal flange in the right, are short and straight or slightly curved. Soft tissues are described as white to off-white. Individuals approaching 5 inches (127 mm) in length have been collected in Texas. The Louisiana Pigtoe is a medium-sized freshwater mussel (shell lengths to greater than 62 mm) with a brown to black, triangular to subquadrate shell without external sculpturing, sometimes with greenish rays. Burlakova et al. (2011a, p. 158) considered the species rare throughout its range. Other native mussel species (e.g. Pimpleback, Cyclonaias pustulosa; Texas Pigtoe, Fusconaia askewi; Trinity Pigtoe, F. chunii; and Wabash Pigtoe, F. flava) can easily be mistaken for Louisiana Pigtoe when identified by shell morphology alone. A recent survey suggested experienced malacologists had a 76% success rate accurately identifying the species in the Little River, Oklahoma, when field identifications were compared with genetic analysis results (USFWS, 2022).

Taxonomy

This report follows the most recently published and accepted taxonomic treatment of North American freshwater mussels as provided by Williams et al. (2017a, entire) which applies to the species assessed in this report. PHYLUM Mollusca Linnaeus, 1758 CLASS Bivalvia Linnaeus, 1758 ORDER Unionida Gray, 1854 FAMILY Unionidae Rafinesque, 1820 SUBFAMILY Ambleminae Rafinesque, 1820 Louisiana Pigtoe and Texas Heelsplitter, along with approximately 85% of North American mussel species, belong to the subfamily Ambleminae. Generally speaking, members of this group share the following common characteristics: 1) are typically slow-growing and commonly live for more than twenty years, with growth rates typically between 1–5mm/year, depending on conditions (Howells et al. 1996, p.17), 2) are frequently summer breeders (Howells et al. 1996, p. 9) although the Lampsilini (e.g., Texas Heelsplitter) typically spawn in fall and brood through the winter, 3) possess either unhooked or axe-head-type glochidia; may brood larvae in either all four or the outer two (lateral) demibranchs (McMahon and Bogan 2001, p. 342), 4) glochidia attach primarily to gills of the host fish (Barnhart et al. 2008, p. 375), 5) produce and store conglutinates in their mantle to facilitate rapid discharge of glochidia when fish attempt to feed (Barnhart et al. 2008, p. 375) and 6) free glochidia (not attached) may be released to water for hours or weeks prior to host infestation (USFWS, 2022).

Historical Range

The species historical range included Arkansas, Louisiana, Texas. We assume the historical distribution of the species would have included the entirety of the river basins described above where connectivity was not an issue and conditions were suitable (see stream segments highlighted black on Figure 3.1)(Note: our estimates of historical range include the mainstem and major tributaries within basins, but do not include an often vast network of minor tributaries even though these areas may have been occupied by mussels in the past) (USFWS, 2022).

Current Range

The range of the Louisiana Pigtoe is comprised of multiple river drainages throughout portions of east Texas, Louisiana, west Mississippi, southeast Oklahoma, and southwest Arkansas (Vidrine 1993, p.66; Howells et al. 1997, p.22; Randklev et al. 2013b, p. 269; Randklev 2018, entire). In Texas, the Louisiana Pigtoe has been recorded from several east Texas rivers, including the Big Cypress-Sulphur, Neches-Angelina, Sabine, San Jacinto, and Trinity River basins (Strecker 1931, p.29; Howells et al. 1996, p. 91; Howells 1997, p. 22; Howells 2006, p. 98; Burlakova et al. 2012, p. 12; D. Ford 2013, pp. 75 – 80; Ford et al. 2014, p. 10; Ford et al. 2016, p. 20; Randklev 2018, entire) (see Figure 3.1). In Louisiana, the species has been recorded within the Amite, Bayou Boeuf, Calcasieu, Red, Sabine, and Pearl River systems (Vidrine 1993, p.66; Randklev et al. 2013b, p. 269; LNHP 2018, entire; Randklev 2018, entire; Johnson et al. 2019, p. 11). In Mississippi, the species has been observed from the Pearl River (Johnson et al. 2019, p. 11). In Arkansas, the species has been recorded in the Cossatot, Saline, Rolling Fork, and Little Rivers (USFWS 2014, p. 29; USFWS 2015, p. 5; USFWS 2017, p. 8; Randklev 2018, entire). In Oklahoma, the species has been recorded in the mainstem of the Little River (Inoue 2018, p. 1). Reported populations from the Ouachita River system in Arkansas were determined to be phylogenetically distinct from Louisiana Pigtoe and are not considered in this report (USFWS, 2022).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Food Source

<u>Adult:</u> phytoplankton, zooplankton, rotifers, protozoans, detritus and dissolved organic matter from the water column (USFWS, 2022)

Food/Nutrient Narrative

<u>Adult:</u> Adult freshwater mussels, including Louisiana Pigtoe and Texas Heelsplitter, are filter-feeders, siphoning suspended phytoplankton, zooplankton, rotifers, protozoans, detritus and dissolved organic matter from the water column (Strayer et al. 2004, p. 430) and from sediment; juvenile mussels are capable of using their foot to collect food items from sediments (pedal feeding; Vaughn et al. 2008, pp. 409- 411). Glochidia derive what little nutrition they need from their obligate fish hosts (Barnhart et al. 2008, p. 372). Stable isotope studies suggest some mussel species feed on coarse particulate organic matter (CPOM) or bacteria and fungi associated with and decomposing the CPOM (Bonner et al. 2018, pp. 7, 215). Freshwater mussels must keep their shells open (gaped) to obtain food and facilitate gas exchange. They are sometimes able to sense perturbations to water quality and may respond by temporarily closing their shells (Bonner et al. 2018, p. 141). Food supply is not generally considered limiting in the environments inhabited by Louisiana Pigtoe and Texas Heelsplitter (USFWS, 2022).

Lifespan

Adult: Long (USFWS, 2022)

Dependency on Other Individuals or Species

Adult: Fish hosts (USFWS, 2022)

Breeding Season

Adult: Hinkle (2018) reported male gametogenesis occurred from mid-July through mid-August with peak production occurring at 30°C (p. 19). Male gametes were flagellated and had an average length of 4.2 micrometers (µm), average width of 1.96 µm, and were found in concentrations ranging from 500,000 to approximately 20,000,000 gametes per milliliter. Female gametogenesis occurred from March through September with peak production at 25°C in early September through early October (Hinkle 2018, p. 19, 21). In females, concentrations of gametes ranged from 0 (but with clusters of oogonia and oocytes) up to 219,400 nonviable ova and 173,200 viable ova and averaged 12,500 nonviable and viable ova among sampled sexually mature females (USFWS< 2022).

Other Reproductive Information

Adult: Fish hosts. Louisiana Pigtoe and Texas Heelsplitter have an obligate parasitic relationship with their respective host fishes. Nearly all freshwater mussels are unable to successfully reproduce or disperse in the absence of appropriate host fish. Host fish are necessary to facilitate dispersal and represent the only mechanism to do so in a free-flowing environment, although downstream movement of individuals may occur during high flow events if they become dislodged from the substrate. Both large and small run of river impoundments act as barriers to fish passage, and therefore inhibit mussel dispersal and recolonization. In some cases, freshwater mussels may be more tolerant of water quality degradation than their host fish. For example, mussels generally prefer dissolved oxygen concentrations greater than 3 mg/L and will begin to experience respiratory distress below approximately 2 mg/L (Bonner et al. 2018, p. 131), but dissolved oxygen below 5 mg/L is generally considered to be harmful to many fish species, and fish mortality is almost certain below 2 mg/L (USFWS, 2022).

Reproduction Narrative

Adult: The reproductive cycle strategy of Louisana Pigtoe is currently unconfirmed. Marshall (2014, pp. 46-47) considered Louisiana Pigtoe to be bradytictic (i.e., longterm brooders; spawning occurs during the summer, glochidia are held by the female over winter and released the following spring); however, gravid females have been observed in July. A closely related congener, Pleurobema plenum, is known to utilize the tachytictic reproductive cycle (i.e., short term brooders; fertilization occurs in the spring and glochidia are expelled during the summer or early fall)(EPA 2007, p. 37). Freshwater mussel recruitment does not occur every year (Ford et al. 2016, p. 28). The primary host fish for Louisiana Pigtoe has not been confirmed. Marshall (2014, pp. 59-60) suggested Bullhead Minnow (Pimephales vigilax), Red Shiner (Cyprinella lutrensis), and Blacktail Shiner (Cypinella venusta) as potential fish hosts based on a fish host distribution modeling effort. When modeled individually, Bullhead Minnow, Red Shiner, Dusky Darter (Percina sciera), and Blacktail Shiner accounted for 47%, 59%, 75%, and 77% of the gain of the full mussel model, respectively (Marshall 2014, pp. 57, 59-60). In this same study, and as part a model validation effort, encysted Louisiana Pigtoe glochidia were collected from wild Bullhead Minnow and Red Shiner from the Neches River; however, none were found encysted on Blacktail Shiner or Dusky Darter. Marshall (2014, p. 60) proposed that since Blacktail Shiner and Red Shiner are closely related and are known to hybridize, they likely serve as hosts to the same freshwater mussel species. Hinkle (2018) collected glochidia infected wild fish from the upper Neches River and kept them under laboratory conditions through glochidia metamorphosis. Results indicated six genetically confirmed Louisiana Pigtoe juveniles excysted from Blacktail Shiners (USFWS, 2022).

Habitat Type

Adult: medium to large-sized streams and rivers (USFWS, 2022)

Habitat Narrative

Adult: Louisiana Pigtoe occur in medium to large-sized streams and rivers in flowing waters (0.3-1.4 m/s) over substrates of cobble and rock or sand, gravel, cobble, and woody debris; they are often associated with riffle, run, and sometimes larger backwater tributary habitats (Ford et al. 2016, pp. 42, 52; Howells 2010a, p. 3-4; Williams et al. 2017b, p. 21). Specimens are typically found in shallower waters (0.1-1.2 m in depth; Howells 2010a, p. 3); however, recent surveys found Louisiana Pigtoe as deep as 3.33 m in the lower Neches River (Bio-West 2019, unpublished data). Other specimens collected from the Neches River occupied substrates of gravel mixtures at depths between 0.57-1.12 m in run habitat with flow velocities of 0.44-0.66 m/s (USFWS, 2022).

Dispersal/Migration

Population Information and Trends

Population Trends:

Declining (USFWS, 2022)

Resiliency:

For these species to maintain viability, their populations or some portion thereof must be resilient to disturbance from stochastic events that vary in duration and intensity. Stochastic events that have the potential to affect mussel populations include 1) high flow events that result in scouring, mobilization of substrates, and burial of mussel beds by large amounts of sediment (these events include flash floods following heavy rains, bank collapse events, etc.), 2) extended droughts and other dewatering events, 3) changes to water quality, including the ongoing or episodic discharge of environmental pollutants or hazardous materials (e.g., oil spill), 4) large-scale depredation events (e.g., collection, natural predation), 5) disease outbreaks, and 6) changes to basic water chemistry (e.g., high water temperature, episodes of low dissolved oxygen). A number of factors influence the resiliency of populations, including occupied stream length, abundance, and recruitment. Elements of occupied habitat such as water quality and hydrologic conditions also influence resiliency by controlling whether mussel populations can grow to maximize habitat occupancy, thereby increasing the resiliency of populations. These factors that affect population resiliency and habitat utilization are discussed in greater detail below in the context of how they meet the needs of mussels, how they were defined for the purposes of our analysis, and how they were used to evaluate population resiliency (USFWS, 2022).

Representation:

Maintaining species representation in the form of genetic and ecological diversity is important in safeguarding the ability of Louisiana Pigtoe and Texas Heelsplitter populations to adapt to future environmental changes. Mussel species like the Louisiana Pigtoe and Texas Heelsplitter need to retain populations throughout their range to maintain their overall potential, both genetically and ecologically (i.e., across habitats with varying capacity to meet life history attributes), to appropriately buffer the species against stochastic events and maintain their ability to respond to environmental changes over time (Jones et al. 2006, p. 531). The genetic diversity of populations of Louisiana Pigtoe and Texas Heelsplitter is unknown, although both species may have lost genetic diversity as populations have contracted over time or been reduced or extirpated by human activities. As such, maintaining the remaining representation in the form of genetic and ecological diversity will be important to preserving the capacity of these populations to adapt to future environmental change. The major river basins within the historical distribution of the Louisiana Pigtoe described in section 3.A.1. span across multiple states and ecoregions, including Blackland Prairie, East Central Plains, and South Central Plains in Texas, the Ouachita Mountains of Oklahoma and Arkansas, and the Rolling and Coastal Plains of Mississippi. The major river basins within the historical distribution of the Texas Heelsplitter described in section 3.A.2. span multiple ecoregions in Texas, including Cross Timbers, Blackland Prairie, East Central Plains, and South Central Plains. Maintaining this ecological and spatial diversity in the future will be important to preserve representation for both species. For our analysis, we considered each river basin to be a separate representation area (USFWS, 2022).

Redundancy:

Both the Louisiana Pigtoe and Texas Heelsplitter need multiple resilient populations distributed throughout their range to provide adequate redundancy. The more populations that exist, particularly densely populated populations, and the wider the distribution of those populations, the more redundancy the species will exhibit. Redundancy reduces the risk that a large portion of the species' range will be negatively affected by a single catastrophic natural or anthropogenic-induced event at any given point in time. Species that are well-distributed across their historical range are considered less susceptible to extinction and more likely to remain viable compared to species that are confined to a small portion of their historical range (Carroll et al. 2010, entire; Redford et al. 2011, entire). Historically, populations of both mussel species were hydrologically connected by fish migration within each river basin including their tributaries. Impoundments and other barriers to fish movement, such as river reaches with unsuitable water quality (e.g., high salinity or temperature), effectively isolate populations from one another, making repopulation of extirpated locations from nearby populations unlikely without human intervention (i.e., active restocking) (USFWS, 2022).

Threats and Stressors

Stressor: Altered hydrology (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Altered hydrology (USFWS, 2022)

Stressor: Direct Mortality (USFWS, 2022)
Exposure:
Response:

Consequence:
Narrative: Direct Mortality (USFWS, 2022)

Stressor: Invasive species (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Invasive species (USFWS, 2022)

Stressor: Climate change (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Climate change (USFWS, 2022)

Stressor: Changes in water quality (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Water quality can be degraded through contamination or alteration of water chemistry. Environmental contaminants include a broad array of natural, synthetic, and chemical substances introduced to the environment that can be hazardous to living organisms. Chemical contaminants are ubiquitous throughout the environment and are a major contributor to the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Contaminants that enter the environment are generally categorized by their origin as either coming from point sources such as hazardous spills, industrial wastewater, and municipal effluents, or non-point sources such as urban stormwater and agricultural runoff. These discharges can introduce a variety of pollutants to air, water and soil, including organic compounds, trace metals, pesticides, plastics, petroleum hydrocarbons, flame retardants, and a wide variety of emerging contaminants (e.g., pharmaceuticals and personal care products) that comprise some 85,000 chemicals in commerce today and are routinely released into the aquatic environment (EPA 2018, p. 1). The extent to which environmental contaminants adversely affect aquatic biota can vary depending on many site-specific variables (e.g., the concentration of the pollutant, the volume discharged, and the timing of the release), but species diversity and abundance consistently ranks lower in waters that are known to be polluted or otherwise impaired by contaminants. For example, freshwater mussels are not generally found for many miles downstream of municipal wastewater treatment plants (WWTP)(Gillis et al. 2017, p. 460; Goudreau et al. 1993, p. 211; Horne and McIntosh 1979, p. 119). Transplanted common freshwater mussels (Amblema plicata and Corbicula fluminea) showed reduced growth and survival below a WWTP outfall relative to sites located upstream of the WWTP in Wilbager Creek (a tributary to the Colorado River in Travis County, Texas); water chemistry was altered by the wastewater flows at downstream sites, with elevated constituents in the water column that included copper, potassium, magnesium, and zinc (USFWS, 2022).

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

USFWS. 2022. Species status assessment report for two freshwater mussels: Louisiana Pigtoe (Pleurobema riddellii) and Texas Heelsplitter (Potamilus amphichaenus). Version 1.2. February 2022. Arlington, Texas.

SPECIES ACCOUNT: *Pleurobema strodeanum* (Fuzzy pigtoe)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/10/2012; Southeast Region (Region 4) (USFWS, 2012)

Physical Description

A medium-sized, subtriangular, thick-shelled freshwater mussel. The fuzzy pigtoe is a small mussel that attains a maximum length of 58 mm. The shell is moderately thick, subtriangular in outline, with a rounded anterior margin and a bluntly pointed posterior margin. The posterior ridge is poorly defined and the posterior slope is slightly concave. Externally, the periostracum is cloth-like, and varies in color from dark olive to brown to almost black. Internally, the pseudocardinal teeth are heavy, and triangular, with two divergent teeth in left valve and one in the right. The lateral teeth are short and almost straight. The nacre is bluish-white with a slight iridescent hue (Williams et al., 2000; Garner et al., in review; Deyrup and Franz, 1994). The length is 5cm and the width is 3cm (NatureServe, 2015)

Taxonomy

There is some confusion regarding the taxonomy and distribution of Gulf slope Pleurobema (Brim Box and Williams, 2000). Heard (1979) listed Pleurobema pyriforme from the Apalachicola, Ochlockonee and Suwannee drainages, and included the Apalachicola River drainage in the distribution of Pleurobema strodeanum. Based upon recent genetic data (Kandl et al., 1997), Brim Box and Williams (2000) recognized only one species, P. pyriforme, from the Suwannee River drainage west to the Econfina Creek drainage, an independent coastal drainage located between the Choctawhatchee and Chipola rivers in west Florida. Therefore, the records of Pleurobema reclusum in Williams and Butler (1994) from the Suwannee and Ochlockonee rivers and Heard's (1979) records of P. strodeanum from the Apalachicola drainage are P. pyriforme. P. strodeanum occurs only in the Escambia, Choctawhatchee and Yellow rivers in west Florida and Alabama. The type locality is in the Escambia River, west Florida (Wright, 1898). (NatureServe, 2015)

Historical Range

Due to recent status surveys the historical range of the fuzzy pigtoe has been expanded (Williams et al., 2000; Blalock-Herod et al., 2005). Within the Escambia River drainage, the fuzzy pigtoe has been found in the Escambia River, Escambia and Santa Rosa Counties, Florida; Conecuh River, Escambia, Covington, Crenshaw, and Pike Counties, Alabama; Murder, Sandy, and Burnt Corn Creeks, Conecuh County, Alabama; Sepulga River, Conecuh County, Alabama; Pigeon Creek, Covington County, Alabama; Patsaliga and Little Patsaliga Creeks, Crenshaw County, Alabama; and Mill Creek, Pike County, Alabama. Within the Yellow River drainage, the fuzzy pigtoe is known from the Yellow River, Covington County, Alabama. Within the Choctawhatchee River drainage, the fuzzy pigtoe was known from Choctawhatchee River, Washington, Walton, and Holmes Counties, Florida; Limestone Creek, Walton County, Florida; Wrights Creek, Holmes County, Florida; Holmes Creek, Washington County, Florida; Choctawhatchee River, Geneva and Dale Counties, Alabama; Little Choctawhatchee River, Dale and Houston Counties, Alabama; Panther Creek, Houston County, Alabama; West Fork Choctawhatchee River, Dale and Barbour Counties, Alabama; East Fork Choctawhatchee River, Henry County, Alabama; and Pea River, Geneva, Dale, and Coffee Counties, Alabama (Williams et al., 2000; Blalock-Herod et al., 2005) (see USFWS, 2003). Blalock-Herod et al. (2005) listed this species from 21 historical sites in the Choctawhatchee River drainage, relocated it at 6 and found it at 34 new sites scattered in the upper and lower portions of the river in Alabama and Florida. (NatureServe, 2015)

Current Range

The fuzzy pigtoe is endemic to and still extant in the Escambia, Pea, and Choctawhatchee rivers in Alabama and Florida, and the Yellow River in Alabama (Mirarchi et al., 2004; Williams et al., 2008; Gangloff and Hartfield, 2009). (NatureServe, 2015)

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On October 10, 2012, the U.S. Fish and Wildlife Service designated critical habitafor the fuzzy pigtoe (Pleurobema strodeanum), under the Endangered Species Act of 1973, as amended (77 FR 61663 - 61719).

Critical Habitat Designation

Critical habitat for the fuzzy pigtoe is designated in GCM1: Lower Escambia River, GCM3: Patsaliga Creek, GCM4: Upper Escambia River, GCM5: Yellow River, GCM6: Choctawhatchee River and Lower Pea River, GCM7: Upper Pea River.

Unit GCM1: Lower Escambia River Drainage, Florida and Alabama. Unit GCM1 encompasses 558 km (347 mi) of the lower Escambia River mainstem and 12 tributary streams in Escambia and Santa Rosa Counties, FL, and Escambia, Covington, Conecuh, and Butler Counties, AL. The unit consists of the main channel of the EscambiaConecuh River from the confluence of Spanish Mill Creek, Escambia and Santa Rosa counties, FL, upstream 204 km (127 mi) to the Point A Lake dam, Covington County, AL; Murder Creek from its confluence with the Conecuh River, Escambia County, AL, upstream 62 km (38 mi) to the confluence of Cane Creek, Conecuh County, AL; Burnt Corn Creek from its confluence with Murder Creek, Escambia County, AL, upstream 59 km (37 mi) to County Road 20, Conecuh County, AL; Jordan Creek from its confluence with Murder Creek, upstream 5.5 km (3.5 mi) to Interstate 65, Conecuh County, AL; Mill Creek from its confluence with Murder Creek upstream 2.5 km (1.5 mi) to the confluence of Sandy Creek, Conecuh County, AL; Sandy Creek from its confluence with Mill Creek upstream 5.5 km (3.5 mi) to County Road 29, Conecuh County, AL; Sepulga River from its confluence with the Conecuh River upstream 69 km (43 mi) to the confluence of Persimmon Creek, Conecuh County, AL; Bottle Creek from its confluence with the Sepulga River upstream 5.5 km (3.5 mi) to County Road 42, Conecuh County, AL; Persimmon Creek from its confluence with the Sepulga River, Conecuh County, upstream 36 km (22 mi) to the confluence of Mashy Creek, Butler County, AL; Panther Creek from its confluence with Persimmon Creek upstream 11 km (7 mi) to State Route 106, Butler County, AL; Pigeon Creek from its confluence with the Sepulga River, Conecuh and Covington Counties, upstream 89 km (55 mi) to the confluence of Three Run Creek, Butler County, AL; and Three Run Creek from its confluence with Pigeon Creek upstream 9 km (5.5 mi) to the confluence of Spring Creek, Butler County, AL. Unit GCM1 is within the geographical area occupied at the time of listing (2012) for the round ebonyshell, southern kidneyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Escambia River system is within the species' historical range, and we consider it essential to the southern kidneyshell's conservation due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. The unit currently supports populations of round ebonyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, cooccur with these five species. A diverse fish fauna, including potential fish host(s) for the fuzzy pigtoe, are known from the Escambia River drainage, indicating the potential presence of PCE 5. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to two upstream impoundments. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM3: Patsaliga Creek Drainage, Alabama. Unit GCM3 encompasses 149 km (92 mi) of Patsaliga Creek and two tributary streams in Covington, Crenshaw, and Pike Counties, AL, within the Escambia River basin. The unit consists of the Patsaliga Creek mainstem from its confluence with Point A Lake at County Road 59, Covington County, AL, upstream 108 km (67 mi) to Crenshaw County Road 66-Pike County Road 1 (the creek is the county boundary), AL; Little Patsaliga Creek from its confluence with Patsaliga Creek upstream 28 km (17 mi) to Mary Daniel Road, Crenshaw County, AL; and Olustee Creek from its confluence with Patsaliga Creek upstream 12 km (8 mi) to County Road 5, Pike County, AL. Unit GCM3 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Patsaliga Creek system is within the species' historic range. We consider it essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the Patsaliga Creek drainage, indicating the potential presence of PCE 5. Prior to construction of the Point A Lake and Gantt Lake dams in 1923, Patsaliga Creek drained directly to the Conecuh River main channel. It now empties into Point A Lake and is effectively isolated from the main channel by the dams. The dams are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM4: Upper Escambia River Drainage, Alabama. Unit GCM4 encompasses 137 km (85 mi) of the Conecuh River mainstem and two tributary streams in Covington, Crenshaw, Pike, and Bullock Counties, AL, within the Escambia River drainage. The unit consists of the Conecuh River from its confluence with Gantt Lake reservoir at the Covington-Crenshaw County line upstream 126 km (78 mi) to County Road 8, Bullock County, AL; Beeman Creek from its confluence with the Conecuh River upstream 6.5 km (4 mi) to the confluence of Mill Creek, Pike County, AL; and Mill Creek from its confluence with Beeman Creek, upstream 4.5 km (3 mi) to County Road 13, Pike County, AL. Unit GCM4 is is within the geographical area occupied at the time of listing (2012) Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Conecuh River is within the species' historic range, and we consider it to be essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species requiring similar PCEs co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the upper Escambia River drainage, indicating the potential presence of PCE 5. The Point A Lake and Gantt Lake dams on the Conecuh River mainstem are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM5: Yellow River Drainage, Florida and Alabama. Unit GCM5 encompasses 247 km (153 mi) of the Yellow River mainstem, the Shoal River mainstem, and three tributary streams in Santa Rosa, Okaloosa, and Walton Counties, FL, and Covington County, AL. The unit consists of the Yellow River from the confluence of Weaver River (a tributary located 0.9 km (0.6 mi), downstream of State Route 87), Santa Rosa County, FL, upstream 157 km (97 mi) to County Road 42, Covington County, AL; the Shoal River from its confluence with the Yellow River, Okaloosa County, FL, upstream 51 km (32 mi) to the confluence of Mossy Head Branch, Walton County, FL; Pond Creek from its confluence with Shoal River, Okaloosa County, FL, upstream 24 km (15 mi) to the confluence of Fleming Creek, Walton County, FL; and Five Runs Creek from its confluence with the Yellow River upstream 15 km (9.5 mi) to County Road 31, Covington County, AL. Unit GCM5 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell was known from the Yellow River drainage; however, its occurrence in the basin is based on the collection of one specimen in 1919 from Hollis Creek in Alabama. We believe this single, historical record is not sufficient to consider this unit as essential to the conservation of the southern kidneyshell. Therefore, we are not designating Unit GCM5 as critical habitat for the southern kidneyshell at this time. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna are known from the Yellow River drainage, indicating the potential presence of PCE 5.

Unit GCM6: Choctawhatchee River and Lower Pea River Drainages, Florida and Alabama. Unit GCM6 encompasses 897 km (557 mi) of the Choctawhatchee River mainstem, the lower Pea River mainstem, and 29 tributary streams in Walton, Washington, Bay, Holmes, and Jackson Counties, FL, and Geneva, Coffee, Dale, Houston, Henry, Pike, and Barbour Counties, AL. The unit consists of the Choctawhatchee River from the confluence of Pine Log Creek, Walton County, FL, upstream 200 km (125 mi) to the point the river splits into the West Fork Choctawhatchee and East Fork Choctawhatchee rivers, Barbour County, AL; Pine Log Creek from its confluence with the Choctawhatchee River, Walton County, upstream 19 km (12 mi) to the confluence of Ditch Branch, Washington and Bay Counties, FL; an unnamed channel forming Cowford Island from its downstream confluence with the Choctawhatchee River upstream 3 km (2 mi) to its upstream confluence with the river, Washington County, FL; Crews Lake from its western terminus 1.5 km (1 mi) to its eastern terminus, Washington County, FL (Crews Lake is a relic channel southwest of Cowford Island, and is disconnected from the Cowford Island channel, except during high flows); Holmes Creek from its confluence with the Choctawhatchee River, Washington County, FL, upstream 98 km (61 mi) to County Road 4, Geneva County, AL; Alligator Creek from its confluence with Holmes Creek upstream 6.5 km (4 mi) to County Road 166, Washington County, FL; Bruce Creek from its confluence with the Choctawhatchee River upstream 25 km (16 mi) to the confluence of an unnamed tributary, Walton County, FL; Sandy Creek from its confluence with the Choctawhatchee River, Walton County, FL, upstream 30 km (18 mi) to the confluence of West Sandy Creek, Holmes and Walton County, FL; Blue Creek from its confluence with Sandy Creek, upstream 7 km (4.5 mi) to the confluence of Goose Branch, Holmes County, FL; West Sandy Creek from its confluence with Sandy Creek, upstream 5.5 km (3.5 mi) to the confluence of an unnamed tributary, Walton County, FL; Wrights Creek from its confluence with the Choctawhatchee River, Holmes County, FL, upstream 43 km (27 mi) to County Road 4, Geneva County, AL; Tenmile Creek from its confluence with Wrights Creek upstream 6 km (3.5 mi) to the confluence of Rice Machine Branch, Holmes County, FL; West Pittman Creek from its confluence with the Choctawhatchee River upstream 6.5 km (4 mi) to Fowler Branch, Holmes County, FL; East Pittman Creek from its confluence with the Choctawhatchee River upstream 4.5 km (3 mi) to County Road 179, Holmes County, FL; Parrot Creek from its confluence with the Choctawhatchee River upstream 6 km (4 mi) to Tommy Lane, Holmes County, FL; the Pea River from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 91 km (57 mi) to the Elba Dam, Coffee County, AL; Limestone Creek from its confluence with the Pea River upstream 8.5 km (5 mi) to Woods Road, Walton County, FL; Flat Creek from the Pea River upstream 17 km (10 mi) to the confluence of Panther Creek, Geneva County, AL; Eightmile Creek from its confluence with Flat Creek, Geneva County, AL, upstream 15 km (9 mi) to the confluence of Dry Branch (first tributary upstream of County Road 181), Walton County, FL; Corner Creek from its confluence with Eightmile Creek upstream 5 km (3 mi) to State Route 54, Geneva County, AL; Natural Bridge Creek from its confluence with Eightmile Creek Geneva County, AL, upstream, 4 km (2.5 mi) to the Covington-Geneva County line, AL; Double Bridges Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 46 km (29 mi) to the confluence of Blanket Creek, Coffee County, AL; Claybank Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 22 km (14 mi) to the Fort Rucker military reservation southern boundary, Dale County, AL; Claybank Creek from the Fort Rucker military reservation northern boundary, upstream 6 km (4 mi) to County Road 36, Dale County, AL; Steep Head Creek from the Fort Rucker military reservation western boundary, upstream 4 km (2.5 mi) to County Road 156, Coffee County, AL; Hurricane Creek from its confluence with the Choctawhatchee River upstream 14 km (8.5 mi) to State Route 52, Geneva County, AL; Little Choctawhatchee River from its confluence with the Choctawhatchee River, Dale and Houston Counties upstream 20 km (13 mi) to the confluence of Newton Creek, Houston County, AL; Panther Creek from its confluence with the Little Choctawhatchee River, upstream 4.5 km (2.5 mi) to the confluence of Gilley Mill Branch, Houston County, AL; Bear Creek from its confluence with the Little Choctawhatchee River, upstream 5.5 km (3.5 mi) to County Road 40 (Fortner Street), Houston County, AL; West Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 54 km (33 mi) to the fork of Paul’s Creek and Lindsey Creek, Barbour County, AL; Judy Creek from its confluence with West Fork Choctawhatchee River upstream 17 km (11 mi) to County Road 13, Dale County, AL; Sikes Creek from its confluence with West Fork Choctawhatchee River, Dale County, AL, upstream 8.5 km (5.5 mi) to State Route 10, Barbour County, AL; Paul’s Creek from its confluence with West Fork Choctawhatchee River upstream 7 km (4.5 mi) to one mile upstream of County Road 20, Barbour County, AL; Lindsey Creek from its confluence with West Fork Choctawhatchee River upstream 14 km (8.5 mi) to the confluence of an unnamed tributary, Barbour County, AL; an unnamed tributary to Lindsey Creek from its confluence with Lindsey Creek upstream 2.5 km (1.5 mi) to 1.0 mile upstream of County Road 53, Barbour County, AL; and East Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 71 km (44 mi) to County Road 71, Barbour County, AL. Unit GCM6 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the Choctawhatchee River, including a potential fish host for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. Not included in this unit are two oxbow lakes now disconnected from the Choctawhatchee River main channel in Washington County, Florida. Horseshoe Lake has a record of southern kidneyshell from 1932, and Crawford Lake has records of Choctaw bean and tapered pigtoe from 1934. It is possible these oxbow lakes had some connection to the main channel when the collections were made over 75 years ago. The three species are not currently known to occur in Horseshoe or Crawford lakes, and we do not consider them essential to the conservation of the southern kidneyshell, Choctaw bean, or tapered pigtoe. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to the Elba Dam on the Pea River mainstem. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM7: Upper Pea River Drainage, Alabama. Unit GCM7 encompasses 234 km (145 mi) of the upper Pea River mainstem and six tributary streams in Coffee, Dale, Pike, Barbour, and Bullock Counties, AL. This unit is within the Choctawhatchee River basin and includes the stream segments upstream of the Elba Dam. The unit consists of the Pea River from the Elba Dam, Coffee County, upstream 123 km (76 mi) to State Route 239, Bullock and Barbour Counties, AL; Whitewater Creek from its confluence with the Pea River, Coffee County upstream 45 km (28 mi) to the confluence of Walnut Creek, Pike County, AL; Walnut Creek from its confluence with Whitewater Creek upstream 14 km (9 mi) to County Road 26, Pike County, AL; Big Creek (Coffee County) from its confluence with Whitewater Creek, Coffee County, upstream 30 km (18 mi) to the confluence of Smart Branch, Pike County, AL; Big Creek (Barbour County) from its confluence with the Pea River upstream 10 km (6 mi) to the confluence of Sand Creek, Barbour County, AL; Pea Creek from its confluence with the Pea River upstream 6 km (4 mi) to the confluence of Hurricane Creek, Barbour County, AL; and Big Sandy Creek from its confluence with the Pea River upstream 6.5 km (4 mi) to County Road 14, Bullock County, AL. Unit GCM7 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the upper Pea River, including potential fish host(s) for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. The Elba Dam on the Pea River mainstem is a barrier to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological feature includes the absence of potential host fishes.

Primary Constituent Elements/Physical or Biological Features

Within the critical habitat areas, the primary constituent elements of the physical or biological features essential to the conservation of the fuzzy pigtoe consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to this mussel and its habitat are pervasive and common in all of the units that are designated as critical habitat. These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas designated as critical habitat are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species. Adults are detritivores and larvae are parasitic (NatureServe, 2015). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column. Juveniles typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994, pp. 200–221; Gatenby et al. 1996, p. 604) (USFWS, 2012).

Reproduction Narrative

Adult: White et al. (2008) tested host suitability on 20 potential fish species and confirmed transformation only on Cyprinella venusta (blacktail shiner). Conglutinates were creamy or peach-colored and wide with a flattened appearance (NatureServe, 2015). It is a short-term brooder, with females gravid from mid-March to May (USFWS, 2012).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (USFWS, 2012; see threats)

Environmental Specificity

Adult: Unknown (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low to moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: It is found in medium-sized creeks and rivers, in sand and silty sand substrates with slow to moderate current (Williams and Butler, 1994; Williams et al., 2000). This species is highly to moderately vulnerable and the environmental specificity is unknown. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). Primary constituent elements include geomorphically stable stream and river channels and banks; stable substrates of sand or mixtures of sand with clay or gravel; a hydrologic flow regime necessary to maintain benthic habitats; water quality, including temperature (not greater than 32 oC), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 mg/L) (USFWS, 2012).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 30-50% (NatureServe, 2015)

Number of Populations:

3 (USFWS, 2022)

Population Size:

Unknown (NatureServe, 2015)

Adaptability:

Low (inferred from USFWS, 2012)

Population Narrative:

Presumable sensitive to excessive siltation and habitat modifications; typical liabilities of filter-feeders (e.g., to excessive pollutants, eutrophication, etc.); reduction in host fish populations is a possibility. Although uncommon, it is still extant in all three drainages where it was known historically in Alabama (Williams et al., 2008). This species has experienced a long-term decline of 30-50%. The range extent is 100 - 400 square miles, with an unknown population size. There are 6 - 80 occurrences, with 1 - 12 having good viability/integrity (NatureServe, 2015). The fuzzy pigtoe is considered vulnerable to extinction because of its limited distribution and dwindling habitat by McGregor (2004, p. 101) (USFWS, 2012). Abundance, population trends, demography: Fuzzy Pigtoe records are known from the Escambia, Yellow, and Choctawhatchee River basins in Alabama and Florida (Fig. 9). Based on available data, the species is likely declining overall in the Escambia River basin. It is exceedingly rare in the Yellow River basin, and the viability of this population appears tenuous. In the Choctawhatchee River basin, relatively abundant Fuzzy Pigtoe populations occur within a few high-quality reaches, but populations are declining elsewhere within the basin. Fuzzy Pigtoe current (2000–2021) occurrences are discussed below and summarized by subbasin in Appendix A. Escambia River Basin A total of 194 live individuals were detected in the basin since 2000. The majority (n=147) were observed in the Escambia subbasin, and it appears to be maintaining populations in the lower mainstem. Too few surveys have been conducted in the upper portions of its range to fully assess it status in the Sepulga, Patsaliga, and Upper Conecuh subbasins; however, based on available data it appears to be declining in those stream systems. Yellow River Basin Since 2000, only three live individuals have been detected in the basin. Two individuals were found in the Five Runs Creek stream system in Alabama, representing new records for that system. Despite considerable sampling effort within its mainstem historical range, only one live individual was detected in recent years. Choctawhatchee River Basin A total of 1,346 live individuals were detected in the basin since 2000. The majority (n = 935) of which were observed within the Pea subbasin, where relatively abundant populations occur within a few high-quality reaches, including Eightmile Creek, upper Pea River, West Fork Choctawhatchee River, and lower Choctawhatchee River. Overall, the species appears to be maintaining populations in the basin, but it is locally extirpated at some historical locations (USFWS, 2022).

Threats and Stressors

Stressor: Sedimentation (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Sedimentation can cause direct mortality of mussels by deposition and suffocation (Ellis, 1936; Brim Box and Mossa, 1999) and can eliminate or reduce the recruitment of juvenile mussels (Negus, 1966; Brim Box and Mossa, 1999). Suspended sediment can also interfere with feeding activity of mussels (Dennis, 1984). Many of the confirmed extant populations of this species are in the vicinity of highway and unpaved road crossings due to ease of access for surveyors. Highway and bridge construction and widening could affect populations of these species unless appropriate precautions are implemented during construction to reduce erosion and sedimentation, and maintain water quality standards (NatureServe, 2015).

Stressor: Impoundments (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: The construction of reservoirs and the associated habitat changes (e.g., changes of sediments, flow, water temperature, dissolved oxygen) can directly impact mussel populations (Neves et al., 1997) (NatureServe, 2015).

Stressor: Pollution (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Nutrients, usually phosphorus and nitrogen, may emanate from agricultural fields, residential lawns, livestock feedlots, poultry houses, and leaking septic tanks in levels that result in eutrophication and reduced oxygen levels in small streams (NatureServe, 2015).

Stressor: Stochastic events (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may contribute to the further decline of mussel populations suffering the effects of other threats. Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in stream temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions. The linear nature of their habitat, reduced range, and small population sizes make these eight mussels vulnerable to contaminant spills (USFWS, 2012).

Stressor: Reduced genetic diversity (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153) (USFWS, 2012).

Stressor: Nonindigenous species (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The invasion of the Asian clam (Corbicula fluminea) in these and in other eastern Gulf drainages has been accompanied by drastic declines in populations of native mussels (see observations by Heard 1975, p. 2; and Shelton 1995, p. 4 unpub. report). The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations. The flathead catfish is a large predator native to the central United States, and since its introduction outside its native range, it has altered the composition of native fish populations through predation (Boschung and Mayden 2004, p. 350) (USFWS, 2012).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 11

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.

- Not available - this species does not have a recovery plan or 5 year review.

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES These seven species do not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities, which are included below. Recovery Activities a. Encourage the protection and establishment of wide riparian buffer zones along all streams containing or draining into the historical ranges of these species. Buffers of at least 300 feet in width and consisting of native forest are considered the most protective and effective. A greater width may be necessary to effectively buffer storm water runoff from urban and suburban lands, cultivated fields, and timber harvest operations. b. Restore and increase in-stream habitat and stream connectivity through conservation actions, including but not limited to removing artificial fish migration barriers, bank stabilization, riparian buffer maintenance or augmentation, improving water quality downstream of impoundments, and adherence to BMPs. c. Work with state and federal agencies and private organizations to promote land and water stewardship awareness (e.g., Soil and Water Conservation Districts, Natural Resource Conservation Service (NRCS), State Forestry Commissions, private industry groups, environmental groups, etc.). d. Develop programs and outreach materials to increase public awareness of these species and explain the benefits of protecting stream ecosystems. Monitoring and Research Activities a. Conduct status survey for Round Ebonyshell in the Conecuh River and document habitat conditions. b. Conduct surveys in under sampled portions of their ranges to examine the species' status and habitat conditions. c. Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. d. Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, and age-specific survival. e. Use eDNA as a detection tool to provide up-to-date distributional information, especially for rare or cryptic species like Southern Kidneyshell. Use assays to confirm presence in historical reaches and detect previously unknown populations. f. Conduct long-term monitoring studies of stream thermal regimes, especially during summer low flow conditions. g. Prepare a comprehensive threats assessment that identifies and maps existing and potential threats within the watersheds and identifies activities or practices that may affect the seven mussels or their habitats. Use the assessment to develop SSAs and recovery plans for the species. h. Model future precipitation, temperature, and flow scenarios in the basins to examine the impacts of climate change and consumptive uses. Use the assessment to develop SSAs and recovery plans for the species. i. Model future sea level and flow scenarios to analyze the effects of saltwater encroachment in the lower mainstems during high tide and storm surge events. Use the assessment to develop SSAs and recovery plans for the species. j. Research important life-history traits, such as host fish use, growth, longevity, age at maturity, and fecundity, and incorporate the results into management and protection actions. All partners should be aware of research efforts and results to facilitate the immediate application of results. k. Determine temperature and contaminant sensitivity for each life-stage, and develop recommendations for EPA and state water quality criteria to protect and enhance habitat. l. Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans. m. Study the life history and identify the host fish of the Southern Sandshell, Choctaw Bean, and Round Ebonyshell (USFWS, 2022).

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 FR 61663 - 61719 (October 10, 2012).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

SPECIES ACCOUNT: *Pleurobema taitianum* (Heavy pigtoe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 04/07/1987; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A freshwater mussel or bivalve mollusk which attains an average adult size of about 55 millimeters (mm) or 2.2 inches (in) in length. It averages 40 mm (1.6 in) in height and 34 mm (1.4 in) in width. The shell is yellowish, greenish-yellow, or tawny, sometimes with darker dots. (NatureServe, 2015)

Taxonomy

Not Available

Historical Range

Historically, this species occurred from the Tombigbee River between Columbus, Mississippi and Demopolis, Alabama; the lower Cahaba River, Alabama; and possibly the Coosa River, Alabama; the East Fork Tombigbee River above Amory, Mississippi and the Buttahatchie River in Mississippi (USFWS, 1989). Historical occurrences are known in the Tombigee River drainage in Mississippi (Jones et al., 2005) but it is likely extirpated from that state. McGregor et al. (2000) reported it absent from the Cahaba River, Alabama. (NatureServe, 2015)

Current Range

It was presumed to be extinct, but has just been discovered in the Alabama River at the city of Selma, Dallas and Lowndes Counties, Alabama. Three live specimens were discovered in October, 1997 during joint operations of the U. S. Fish and Wildlife Service and the Alabama Department of Conservation (Paul Hartfield, pers. comm. 10/14/1997) and two more at the same site in 1999. Previously, it was last observed alive in the Tombigbee drainage (Buttahatchee River) in 1987. A small population was found in the Alabama River in 1997 with subsequent collection of two specimens in 1999 in the same location (Paul Hartfield, pers. comm., September 2003). (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species. Adults are detritivores and larvae are parasitic (NatureServe, 2015). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column. Juveniles typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994, pp. 200–221; Gatenby et al. 1996, p. 604) (USFWS, 2012).

Reproduction Narrative

Adult: It is a short-term brooder, gravid in spring and summer (P. Johnson, pers. comm., 2010). The glochidial host is not known (NatureServe, 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species is found in riffles and shoals of small to large rivers on sandy gravel to gravel-cobble substrates and with moderate to fast currents (USFWS, 2000). It is a species of rivers and large creeks; although Williams (1982) reported it from gravel shoals. Substrate where it is found in the Alabame River is composed of gravel with large component of coarse sand in water exceeding 6 m; with variable current (P. Johnson, pers. comm., 2010). This species is highly vulnerable and the environmental specificity is narrow. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of >90% (NatureServe, 2015)

Species Trends:

Declining (USFWS, 2015)

Number of Populations:

1 (USFWS, 2015)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Adaptability:

Very low (inferred from NatureServe, 2015)

Population Narrative:

Low population levels cause increased difficulty in completing successful reproduction. When individuals become scattered, the opportunity for the female to become gravid is greatly diminished. With low populations levels, any impact is a major threat (USFWS, 1989). Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). Historically, this species occurred in the mainstem of the Tombigbee, Alabama, Coosa, and Cahaba Rivers with one isolated record from above the Fall Line in the Black Warrior River (Williams et al., 2008) but is now found only in localized populations in the Alabama and Tombigbee Rivers (Mirarchi, 2004). This species has experienced a long-term decline of >90%. The range extent is less than 40 square miles, with an estimated population size of 1 - 1,000 individuals. The single occurrence does not have good viability/integrity (NatureServe, 2015). The species status is declining; there is a single population with no evidence of recruitment (USFWS, 2015). A single surviving population of heavy pigtoe is known from the Alabama River, Dallas County, Alabama (Hartfield and Garner 1998, Garner and Buntin 2011). The area of habitat supporting mussels at this site has been quantified (6,250 square meters (m2)); based upon quantitative sampling the surviving heavy pigtoe population within this bed was estimated at 81 animals (Garner and Buntin 2011; Service 2015). No evidence of recruitment of heavy pigtoe within this bed has been found since its discovery. Propagation attempts with captive adults have been unsuccessful (Service 2015). There have been no surveys or monitoring of this population since 2011 as cited in the 2015 review. (USFWS, 2021)

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: The primary cause of population decline for Heavy pigtoe is habitat modification for navigation. Construction of the Tennessee-Tombigbee Waterway adversely impacted these mussels by physical destruction during dredging, increasing sedimentation, reducing water flow, and suffocating juveniles with sediment. The upper Tombigbee River was converted from a free-flowing riverine system into a series of impoundments. The remaining habitat in the mainstem Tombigbee River occurs in several bendways resulting from channel cuts. These bendways have experienced reduced flows and increased sediment accumulation (USFWS, 1989).

Stressor: Water diversion (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: Water diversion continues to threaten Stirrupshell, especially in the East Fork Tombigbee River. The Tennessee-Tombigbee Waterway canal section significantly altered water flows from eastern tributaries of the East Fork. Minimum flow structures were built into the Waterway to maintain flows in tributaries from which higher flushing flood flows were diverted. At least one municipality proposes to use the East Fork as a water supply and remove up to 136 million liters or 30 million gallons (gal) per day. Unless the Waterway canal structures continually release the planned amounts of water, the withdrawal of such a large quantity of municipal water would very likely jeopardize the mussels in the East Fork. Should any other water withdrawal occur, there must be corresponding water releases from the Waterway to avoid adverse impacts to mussels. The accumulation of sediment in the East Fork downstream of Mill Creek is likely due to the diversion of flushing flows by the Waterway canal cut from Bull Mountain Creek through the Lock B spillway some 6.4 km (4 mi) downstream (USFWS, 1989).

Stressor: Runoff of fertilizers and pesticides (USFWS 1989)
Exposure:
Response:
Consequence:
Narrative: Runoff of fertilizers and pesticides into these tributaries may adversely impact freshwater mussels. Such runoff can exceed the assimilation ability of the stream and result in algal blooms and excesses of other aquatic vegetation. This condition can produce eutrophication and result in the death of mussels. Pesticides washed into the stream are ingested by filter feeders while being transported downstream. Pesticide-laden silt particles eventually settle to and become part of the substratum, increasing the concentration of pesticides in mussel habitats (USFWS, 1989).

Stressor: Small population size (USFWS 1989, 2009)
Exposure:

Response:
Consequence:
Narrative: The low population levels cause increased difficulty for successful reproduction. When individuals are scattered, the opportunity for a female to siphon sperm and fertilize eggs is diminished. This results in fewer gravid females in proximity to the host species. With low population levels, any event that impacts one of these species is of major significance (USFWS, 1989). A single surviving population in the Alabama River is experiencing recruitment failure (USFWS, 2009).

Recovery

Reclassification Criteria:
The recovery of this species, to a degree that would permit down-listing to threatened, is unlikely due to their few numbers and lack of suitable habitat within their historic range (USFWS, 1989).

Delisting Criteria:
Not available

Recovery Actions:
- Protect the known habitat (USFWS, 1989).
- Determine habitat requirements and management needs (USFWS, 1989).
- Implement management needs (USFWS, 1989).
- Survey populations to determine trends (USFWS, 1989).
- Continue to search for heavy pigtoe; quantify, and monitor surviving populations and habitats (USFWS, 2015).
- Complete the draft Strategic Habitat Conservation Plan for the Buttahatchee River (USFWS, 2015).
- Maintain and enhance conservation partnerships within the Tombigbee drainage and Mobile River Basin (USFWS, 2015).
- Develop and implement a strategic habitat conservation plan for the East Fork Tombigbee River (USFWS, 2015).
- Continue to describe and monitor habitat conditions at potential reintroduction sites (USFWS, 2015).
- Continue to work with States to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS, 2015).
- Continue to work with AABC to propagate and reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2015).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Conduct comprehensive survey for black clubshell in the East Fork Tombigbee River prior to determining extinction. 2. Continue to monitor the Buttahatchee River southern combshell population. 3. Continue to augment and monitor reintroduced southern combshell populations in the Cahaba River and Bull Mountain Creek. 4. Maintain and enhance conservation partnerships within the Tombigbee drainage and Mobile River Basin. Develop and implement a strategic habitat conservation plan for the East Fork Tombigbee River. 5. Continue to support AABC mission to propagate and reintroduce hatchery reared imperiled

mollusks into restored habitats, as appropriate. (USFWS, 2021)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

USFWS 2015. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Jackson Ecological Services Field Office Jackson, Mississippi. USFWS. 2021. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) 5-Year Review: Summary and Evaluation – 2021. U.S. Fish and Wildlife Service South Atlantic-Gulf Region and Mississippi Basin Regions Jackson Ecological Services Field Office Jackson, Mississippi. 13 pp.

U.S. Fish and Wildlife Service. 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 18 pp.

USFWS. 2009. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum), Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli), Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum), Southern Combshell (Penitent Mussel) (Epioblasma penita), Stirrupshell (Quadrula stapes)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jackson Ecological Services Field Office Jackson, Mississippi. 24 pp.

U.S. Fish and Wildlife Service, 1989. Five Tombigbee River Mussels Recovery Plan. U.S. Fish and Wildlife Service. Atlanta, Georgia. 18 pp.

USFWS 2015. Black Clubshell (Curtus' Pearly Mussel) (Pleurobema curtum) Flat Pigtoe (Marshall's Pearly Mussel) (Pleurobema marshalli) Heavy Pigtoe (Judge Tait's Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) Stirrupshell (Quadrula stapes) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Jackson Ecological Services Field Office, Jackson, Mississippi.

USFWS. 2021. Black Clubshell (Curtus’ Pearly Mussel) (Pleurobema curtum) Heavy Pigtoe (Judge Tait’s Mussel) (Pleurobema taitianum) Southern Combshell (Penitent Mussel) (Epioblasma penita) 5-Year Review: Summary and Evaluation – 2021. U.S. Fish and Wildlife Service South Atlantic-Gulf Region and Mississippi Basin Regions Jackson Ecological Services Field Office Jackson, Mississippi. 13 pp.

SPECIES ACCOUNT: *Pleuronaia barnesiana* (Tennessee pigtoe)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

Attaining a maximum length of 95 mm (3.7 in), the Tennessee pigtoe's shape varies from oval to subtriangular or subquadrate, and its shell is yellowish or brown, sometimes with dark green rays (USFWS, 2023)

Taxonomy

Medionidus conradicus, P. oviforme, and P. barnesiana belong to the family Unionidae, also known as the naiads or pearly mussels. North America contains the greatest diversity of freshwater mussels globally, comprising around 300 currently recognized species, with 29 species considered extinct and nearly 200 considered imperiled (Haag and Williams 2014, entire). This SSA follows the most recently published and accepted taxonomic treatment of North American freshwater mussels (Williams et al. 2017, entire). Recent studies have suggested potential genetic overlap between P. oviforme and the federally Endangered Pleurobema clava (Inoue et al. 2018, p. 698), and a potentially distinct form of P. oviforme may exist in the Little River in the upper Tennessee Basin (Schilling 2015, p. 105). Furthermore, the recovery plan and most recent 5-year review of P. clava acknowledges morphological and geographic overlap between P. clava and P. oviforme in the Tennessee and Cumberland River systems (Service 1994, p. 6; Service 2009, p. 11). Because no formal taxonomic changes have been published due to the limited data available, the present analysis treats P. oviforme as a valid species. Genetic analyses are ongoing (J. Jones and C. Morrison 2020, personal communication), and future assessments should carefully consider any taxonomic information published after the writing of this SSA report (USFWS, 2020).

Current Range

It occurs in the Tennessee River drainage, in Alabama, Georgia, North Carolina, Tennessee, and Virginia (see figure 2, below). It is presumed extirpated from Mississippi, where it was known to occur only in Bear Creek, in Tishomingo County. Unlike the Tennessee clubshell and Cumberland moccasinshell, the Tennessee pigtoe does not occur in the Cumberland River drainage (USFWS, 2023).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Broadcast spawning

Lifespan

Adult: 30-50 years (USFWS, 2023)

Breeding Season

Adult: As a short-term brooder, it spawns in the spring and releases glochidia mid-July through early August (USFWS, 2023).

Other Reproductive Information

Adult: The Tennessee pigtoe has a lifespan of 30 years on average but may live to 50 years. Age at maturity ranges from 4 to 6 years. As a short-term brooder, it spawns in the spring and releases glochidia mid-July through early August. The host fishes are unknown for this species but likely are the same as or similar to those of the Tennessee clubshell (USFWS, 2023).

Reproduction Narrative

Adult: Freshwater mussels, including the three species that are the subjects of this proposed rule, have a complex reproduction process involving parasitic larvae, called glochidia, that are wholly dependent on host fish. Mussels release sperm into the water column, which is taken in by the female, wherein fertilization and development of glochidia occurs in a restricted portion of the gills, called the brood pouch or marsupium. When mature, the glochidia are released to the water column to attach on the gills, head, or fins of fishes. Glochidia die if they fail to attach to a host fish, attach to an incompatible fish species, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 599). Once attached to the host, glochidia draw nutrients from the fish's tissue as they develop (Arey 1932, pp. 214–215). Time to development, from attachment of glochidia to maturation, ranges from just over 1 week to 6 weeks or more (Parmalee and Bogan 1998, p. 8). Depending on the species, mussels are either short-term or long-term brooders. In short-term brooders, fertilization occurs in the spring or summer and glochidia are released shortly after they are fully developed. In long-term brooders, fertilization occurs in late summer or fall, and developed glochidia are held over winter and released in the following spring or summer (Haag 2012, pp. 39–40). Mature glochidia drop off their hosts and, if they settle in suitable habitat on the stream bottom, continue the remainder of their existence as freeliving mussels. Newly released glochidia are juveniles that are reproductively immature but otherwise resemble adults, with both halves (valves) of the shell developed and poised for growth (USFWS, 2023)

Habitat Type

Adult: Aquatic

Habitat Narrative

Adult: ife history, and ecology of the Tennessee pigtoe is presented in the SSA report (Service 2020, pp. 3–7). Attaining a maximum length of 95 mm (3.7 in), the Tennessee pigtoe's shape varies from oval to subtriangular or subquadrate, and its shell is yellowish or brown, sometimes with dark green rays (Williams et al. 2008, p. 585). It occurs in the Tennessee River drainage, in Alabama, Georgia, North Carolina, Tennessee, and Virginia (see figure 2, below). It is presumed extirpated from Mississippi, where it was known to occur only in Bear Creek, in Tishomingo County. Unlike the Tennessee clubshell and Cumberland moccasinshell, the Tennessee pigtoe does not occur in the Cumberland River drainage. It is found in moderate current, and rarely in pools and slackwaters, in small streams to large rivers, in a mixture of sand, gravel, and cobble substrates. The Tennessee pigtoe has a lifespan of 30 years on average but may live to 50 years. Age at maturity ranges from 4 to 6 years. As a short-term brooder, it spawns in the spring and releases glochidia mid-July through early August. The host fishes are unknown for this species but likely are the same as or similar to those of the Tennessee clubshell (USFWS, 2023).

Dispersal/Migration

Population Information and Trends

Species Trends:
Declining

Number of Populations:
Currently, it occupies 43 to 63 watersheds, compared to 114 historically, reflecting a range reduction of 42 to 62 percent (USFWS, 2023)

Population Narrative:
The Tennessee pigtoe was once a common species throughout the Tennessee Basin. Currently, it occupies 43 to 63 watersheds, compared to 114 historically, reflecting a range reduction of 42 to 62 percent. Most extant populations of the species are classified as low condition (32), with only three populations classified as high condition and eight populations classified as medium condition, indicating species condition is currently low (see table 3, above). Rangewide, there are three redundant populations with high resiliency, which are likely to withstand the effects of stochastic events, and eight redundant populations with medium resiliency, which may withstand the effects of a stochastic event. The 32 low-condition (low resiliency) populations have little capacity to withstand the effects of a stochastic event and do not contribute to species redundancy or the species' capacity for withstanding catastrophic events. Representation of the Tennessee pigtoe has declined, as populations in the mainstem Tennessee River are extirpated and the connectivity between tributaries is disrupted by impoundments, which has diminished population interaction necessary for maintenance of genetic diversity (USFWS, 2023).

Threats and Stressors

Stressor: Large Impoundments (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Our analysis identified large impoundments (indicated by reservoir surface area) as a rangewide threat to the three mussel species. The Tennessee Valley Authority operates 31 large dams in the Tennessee River system and one large dam (Great Falls Dam) in the Cumberland system (TVA Recreation Map website, 2023) and the U.S. Army Corps of Engineers operates 10 large dams in the Cumberland system (USACE Nashville District website, 2023). The effects of dams on aquatic habitats and freshwater mussels are well-documented (Watters 2000, p. 261), and extinction and extirpations of North American freshwater mussels can be traced to impoundment and inundation of riffle habitats in all major river basins of the central and eastern United States (Haag 2009, p. 107). Dams disrupt population connectivity and alter water quality. After a dam has been constructed, upstream the channel becomes deeper, flow decreases dramatically, and fine sediments accumulate on the channel bottom, which eliminates shoal and riffle habitats needed by the three mussel species, as well as many others, and their host fishes. Downstream of dams, natural flow regimes are disrupted by alternating low flow releases and

pulses of scouring flows (Hardison and Layzer 2001, p. 79), reduced water temperatures, reduced dissolved oxygen, and changes in fish assemblages. Mussels may survive in cold tailwaters but may not be able to reproduce, as was shown for native washboard mussels (Megalonaias nervosa) in the mainstem Cumberland River (Heinricher and Layzer 1999, entire). In a Cumberland River tributary, Caney Fork, the extirpation of several mussel species, including Cumberland moccasinshell, was attributed mainly to cold tailwater temperatures from Center Hill Dam (completed in 1948) and alteration of channel morphology from peaking flows, and no live mussels were found within 7.5 mi (12 km) of the dam outfall (Layzer et al. 1993, pp. 69–70) (USFWS, 2023).

Stressor: Developed Land Use/Urbanization (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: For all three mussel species, development and urbanization contribute to habitat degradation and loss. Freshwater mussel populations may experience reduced abundance, species richness, reproduction, growth, and survival stemming from the impacts of urbanization on water and habitat quality (Diamond and Serveiss 2001, p. 4716; Gangloff et al. 2009, p. 198; Cao et al. 2013, pp. 1212–1214; Gillis et al. 2017, pp. 674–679). The threats analysis in our SSA found the estimated probability of extirpation for all three species approaches 100 percent when developed land area is between 9 and 15 percent of the total land area in a watershed (Service 2020, p. 61). The term ‘‘development’’ refers to urbanization of the landscape, including (but not limited to) land conversion for residential, commercial, and industrial uses and the accompanying infrastructure. Urbanization effects may include alterations to water quality, water quantity, and instream and streamside habitat (Ren et al. 2003, p. 649; Wilson 2015, p. 424). The effects on habitat also include variability in streamflow, typically increasing the extent and volume of water entering a stream after a storm and decreasing the time it takes for the water to travel over the land before entering the stream (Giddings et al. 2009, p. 1). In urbanized environments, storm drains deliver large volumes of water to streams much faster than would naturally occur, often resulting in flooding and bank erosion that reshape the channel and cause substrate instability. Increased, high-velocity discharges can cause species living in streams (including mussels) to become stressed, displaced, or killed by fastmoving water and the debris and sediment carried in it. Once floodwaters recede, displaced individuals may be left stranded out of the water, and fine sediments transported to the stream settle on coarser substrates, which may damage or destroy areas of mussel habitat. During storm events, contaminants in urbanized environments (e.g., gasoline, oil drips, fertilizers) accumulated on impervious surfaces may be washed directly into streams (USFWS, 2023)

Stressor: Energy Development—Coal, Natural Gas, and Oil (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Extraction of coal, natural gas, and (to a lesser extent) oil is common in the Cumberland and Upper Tennessee River basins and has been associated with mussel declines in several watersheds (Layzer and Anderson 1992, entire; Warren and Haag 2005, entire; Johnson et al. 2014, p. 890; TDEC 2014, p. 62; Zipper et al. 2016, pp. 612–613; Ahlstedt et al. 2016, p. 13). Examples of energy development impacts in the range of the three mussels include high levels of copper, manganese, and zinc, metals that can be toxic to freshwater mussels, found in sediment

samples from both the Clinch and Powell Rivers. Both rivers receive runoff from active, reclaimed, and abandoned coal mine sites. In Cumberland Basin streams, including Buck Creek, Horse Lick Creek, Little South Fork, and Rockcastle River, there was a clear correlation between surface mines, increased metal concentrations downstream, and the extirpation of some mussel species (Layzer and Anderson 1992, pp. 91–96). In the upper Powell River, Virginia, coal mining has almost eliminated the mussel fauna; sediment pore water from the riverbed contains levels of contaminants potentially toxic to mussels, particularly selenium and copper (Timpano et al. 2023, p. 13). Natural gas and oil extraction is a threat to freshwater mussels in the Upper Tennessee Basin and Cumberland Basin. In addition to the general impacts of erosion and sedimentation from forest clearing for access roads and installing drill pads, spills from (brine) disposal ponds at gas wells or end-of-pipe discharges from brine treatment facilities can reduce freshwater mussel abundance and diversity, as well as increase mortality. These effects have been observed in the Allegheny River (Patnode et al. 2015, p. 55), a watershed outside the range of the three mussel species, but within the Ohio Basin, which contains the Tennessee River and Cumberland River (USFWS, 2023)

Stressor: Agriculture (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Throughout the range of the three mussel species and have impacted watersheds in the species' historical and current ranges. The advent of intensive row crop agriculture is a potential factor in freshwater mussel decline and species extirpation in the eastern United States (Peacock et al. 2005, p. 550). Nutrient enrichment from fertilized crops and livestock is a threat commonly associated with negative effects on aquatic biota and can increase ammonia concentrations, to which freshwater mussels are particularly sensitive. In addition, agricultural pesticides, including herbicides, fungicides, insecticides, and their surfactants and adjuvants, are highly toxic to juvenile and adult freshwater mussels (Bringolf et al. 2007, p. 2,092). Concentrations of these contaminants from fields or pastures may be at levels that can affect an entire population, especially given the highly fragmented distributions of the three mussel species. Agricultural land use has been associated with decreased freshwater mussel diversity, growth, and survival in North American streams. A temporal analysis of freshwater mussel populations in Iowa streams showed declines in mussel species richness, and local extirpations corresponded with agricultural intensity and forest clearing of the riparian zone (Poole and Downing 2004, pp. 121–124). In those Iowa streams, the segments with the highest substrate diversity exhibited the lowest declines in species richness, indicating homogenization of substrates from sedimentation is a freshwater mussel stressor. Further, species richness increased or was unchanged where agriculture was less than 25 percent of the land use. Another study, in Minnesota streams, revealed decreases in mussel abundance and richness corresponding with increases in agricultural land use (Hornbach et al. 2019, p. 1,833). In Kentucky, streams in proximity to row crop agriculture were associated with higher values of contaminants (pesticides and fertilizers), and growth of caged mussels in those streams was low in comparison with most other streams, where row crops were a minor land use (Haag et al. 2019, pp. 761–763). One of the streams in the study with high row crop land use was the Red River, in the historical range of the Cumberland moccasinshell and with one current low-condition population of the Tennessee clubshell. The abnormally low growth rates observed in the streams in proximity to high row crop land use usually presage early mortality observed in mussel hatchery settings (USFWS, 2023)

Stressor: Contaminants (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Three of the land uses identified as threats to the three mussel species (urban development, energy development, and agriculture) contribute contaminants to stream habitats, which can degrade water and substrate quality and adversely impact individuals and populations. Although chemical spills and other point sources of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result in part from the subtle, pervasive effects of chronic, low-level contamination (USFWS, 2023)

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2020. Species Status Assessment for Three Freshwater Mussels from the Tennessee and Cumberland River Basins (Medionidus conradicus, Pleurobema oviforme, and Pleuronaia barnesiana), Version 1.0. Asheville Ecological Services Field Office, Asheville, North Carolina. USFWS. 2023. FR Vol, 88, No. 161. Pages 57060-57077. Endangered and Threatened Wildlife and Plants

Endangered Species Status for Tennessee Clubshell, Tennessee Pigtoe, and Cumberland Moccasinshell.

USFWS. 2023. FR Vol, 88, No. 161. Pages 57060-57077. Endangered and Threatened Wildlife and Plants

SPECIES ACCOUNT: *Pleuronaia dolabelloides* (Slabside Pearlymussel)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/28/2013; Endangered; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A freshwater mussel. The shell is solid to heavy, subtriangular, compressed to inflated; anterior margin subtruncated, flatly rounded; ventral margin convex; posterior margin obliquely convex, joining ventral margin in a ventrally directed point (often blunt) at the terminus of the posterior ridge, posterior-dorsal junction often barely perceivable; beaks elevated, inclined forward, positioned in the anterior 10% of shell length, sculpted with fine irregularly wavy ridges; shell widest subcentrally, forming a broadly rounded radial ridge from the beak to the ventral margin, slope to posterior ridge flat; posterior ridge lower but distinct, subangular, convex; periostracum yellowish to brown with variously scattered narrow to wide dark green rays, rays appear broken or as blotches due to distinctly elevated termini of annual growth increments. Pseudocardinal teeth moderately large, elevated, rough, double in left valve, single in right with small denticles anterior and posterior to contiguous sulci; interdentum moderately wide, short; lateral teeth long, curved, double in left valve, single in right but may develop a smaller incomplete lamella along ventral margin of hinge plate; anterior muscle scars distinct, small, moderately deep; pallial line impressed, lighter posteriorly; posterior muscle scars distinct, impressed; beak cavity moderately developed; nacre white, may be tinged with yellow, some iridescence posteriorly. The length is 6cm and the width is 3cm. (NatureServe, 2015)

Taxonomy

Lexingtonia was based on the anatomical characters of "Unio subplanus Conrad, 1837" (see Ortmann, 1914). Subsequently, Ortmann (1918) included dolabelloides in this genus. There are only two species formerly classified in Lexingtonia, representing a rather unique, disjunct geographic distribution (Cumberlandian region vs. coastal drainage of Virginia). Although similar to and formerly classified in Pleurobema, Lexingtonia (now Pleuronaia) is distinguished from the latter by its red, subcylindrical glochidial conglutinates and wavy beak sculpture. Pleuronaia dolabelloides has historically been treated as a member of the genus Fusconaia despite differences from other members of the genus (Ortmann, 1917; 1918). Bogan et al. (unpublished) found Lexingtonia subplana is synonymous with Fusconaia masoni and since L. subplana is the type species for the genus, Lexingtonia becomes a synonym of Fusconaia. The next available generic name for barnesiana and dolabelloides is Pleuronaia Frierson, 1927. Pleurobema gibberum was also found to belong to the Pleuronaia clade (see Williams et al., 2008). Pleuronaia dolabelloides exhibits ecophenotypic variation. Shell inflation increases progressively as a function of increasing stream size. Compressed forms found in creeks and smaller rivers were designated Pleuronaia dolabelloides conradi (Vanatta, 1915); inflated dolabelloides were found in larger habitats (see Ortmann, 1918). Ortmann (1920) determined the "two forms pass gradually into each other". Although previously used in a subspecific context, such designation is not consistent with current systematic interpretations. (NatureServe, 2015)

Historical Range

Historically, this species occurred in the lower Cumberland River main stem from about Caney Fork downstream to the vicinity of the Kentucky State line, and in the Tennessee River main stem from eastern Tennessee to western Tennessee. It generally has been considered a

Tennessee River endemic (Simpson, 1914; Bogan and Parmalee, 1983). As a result of the failure of Wilson and Clark (1914) to collect it and the lack of other locality records, Lea's (1871) report of "Unio subglobosus" (junior synonym of Lexingtonia dolabelloides, fide Simpson, 1914) from the Cumberland River in Nashville has been discounted. However, recent finds of relict specimens (e.g., Parmalee et al., 1980; Schuster, 1988) confirm it as a historical component of the Cumberland River fauna (Starnes and Bogan, 1988; Gordon and Layzer, 1989). It is apparently extirpated from the entire Cumberland River system. Most historical records are from the Tennessee River system and indicate that it was a fairly common species found throughout the Cumberlandian region of the drainage. Records are known from two Cumberland River tributaries, Caney Fork and Red River. (NatureServe, 2015)

Current Range

In addition, it is known from nearly 30 Tennessee River system tributaries, including the South Fork Powell River, Powell River, Puckell Creek, Clinch River, North Fork Holston River, Big Moccasin Creek, Middle Fork Holston River, South Fork Holston River, Holston River, French Broad River, West Prong Little Pigeon River, Tellico River, Little Tennessee River, Hiwassee River, Sequatchie River, Paint Rock River, Larkin Fork, Estill Fork, Hurricane Creek, Flint River, Limestone Creek, Elk River, Sugar Creek, Bear Creek, Duck River, North Fork Creek, Big Rock Creek, and Buffalo River. Undocumented, but now lost, populations assuredly occurred in other Cumberlandian Region tributary systems (USFWS, 2003). Populations remain in nine streams in the Tennessee River system: the Powell River, Clinch River, North Fork Holston River, Big Moccasin Creek, Middle Fork Holston River, Hiwasee River, Paint Rock River, Larkin Fork, Estill Fork, Hurricane Creek, Elk River, Bear Creek, and Duck River (USFWS, 2003; Mirarchi et al., 2004). It is also known from Lake Pontchartrain in Mississippi (Jones et al., 2005). (NatureServe, 2015)

Critical Habitat Designated

Yes; 9/26/2013.

Legal Description

On September 26, 2013, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the slabside pearlymussel (Pleuronaia dolabelloides) under the Endangered Species Act of 1973, as amended (78 FR 59555 - 59620).

Critical Habitat Designation

13 critical habitat units encompassing approximately 1,562 rkm (970 rmi) of stream channel in Alabama, Mississippi, Tennessee, and Virginia are designated for the slabside pearlymussel. The 13 areas designated as critical habitat are as follows: (1) North Fork Holston River, VA; (2) Middle Fork Holston River, VA; (3) Big Moccasin Creek, VA; (4) Clinch River, TN, VA; (5) Powell River, TN, VA; (6) Nolichucky River, TN; (7) Hiwassee River, TN; (8) Sequatchie River, TN; (9) Paint Rock River, AL; (10) Elk River, AL, TN; (11) Bear Creek, AL, MS; (12) Duck River, TN; and (13) Buffalo River, TN.

Unit FK11: Little River, Russell and Tazewell Counties, Virginia. Unit FK11 includes approximately 50 rkm (31 rmi) of Little River from its confluence with the Clinch River in Russell County, VA, upstream to its confluence with Liberty and Maiden Spring Creeks in Tazewell County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by fluted kidneyshell at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The Nature Conservancy also owns a small portion of adjacent property. The channel within Unit FK11 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitats may require special management considerations or protection to address potential adverse effects associated with silviculturerelated activities, lack of adequate riparian buffers, natural gas and oil exploration activities in headwater reaches, and nonpoint source pollution originating in headwater reaches.

Unit FK12 and SP1: North Fork Holston River, Smyth and Bland Counties, Virginia. Unit FK12 and SP1 includes approximately 67 rkm (42 rmi) of the North Fork Holston River from its confluence with Beaver Creek, upstream of Saltville, in Smyth County, VA, upstream to Ceres, Bland County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings, road easements, and a small portion that is adjacent to the George Washington and Jefferson National Forests. The Nature Conservancy and the Virginia Outdoors Foundation also own a small portion of adjacent property. A portion of this unit (58 rkm (36 rmi)) has been designated as a NEP for the yellowfin madtom (53 FR 29335). The channel within Unit FK12 and SP1 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities, silviculture-related activities, natural gas and oil exploration activities in headwater reaches, lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK13 and SP2: Middle Fork Holston River, Washington, Smyth, and Wythe Counties, Virginia. Unit FK13 and SP2 includes approximately 89 rkm (55 rmi) of the Middle Fork Holston River from its inundation at South Holston Lake in Washington County, VA, upstream to its headwaters in Wythe County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both the fluted kidneyshell and slabside pearlymussel at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The channel within Unit FK13 and SP2 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities, lack of adequate riparian buffers, silviculture-related activities, and nonpoint source pollution.

Unit FK14 and SP3: Big Moccasin Creek, Scott and Russell Counties, Virginia. Unit FK14 and SP3 includes approximately 33 rkm (21 rmi) of Big Moccasin Creek from the Highway 71 Bridge crossing in Scott County, VA, upstream to the Route 612 Bridge crossing near Collinwood in Russell County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell, but within the species' historical range. Live fluted kidneyshell have not been collected in Big Moccasin Creek since the early 1900s (Ortmann 1918, p. 608). However, this unit is designated as critical habitat for the fluted kidneyshell because it is considered essential for the conservation of the species (see Criteria Used To Identify Critical Habitat above for our rationale). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The channel within Unit FK14 and SP3 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities (livestock), lack of adequate riparian buffers, silviculturerelated activities, natural gas and oil exploration activities in headwater reaches, illegal off-road vehicle use and other recreational activities, and nonpoint source pollution originating in headwater reaches.

Unit FK16 and SP4: Clinch River, Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia. Unit FK16 and SP4 includes approximately 263 rkm (163 rmi) of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island in Hancock County, TN, upstream to its confluence with Indian Creek near Cedar Bluff, Tazewell County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. Approximately 6 rkm (4 rmi) of this unit is in public ownership, including portions of the Kyles Ford State Managed Area, George Washington National Forest, Jefferson National Forest, Cleveland Barrens State Natural Area Preserve (SNAP), and the Pinnacle SNAP. The Nature Conservancy also owns a small portion of adjacent property. The unit completely overlaps critical habitat for the Cumberlandian combshell, rough rabbitsfoot, purple bean, and oyster mussel, and the entire length of this unit has been designated as critical habitat for the slender chub and yellowfin madtom (42 FR 45526, 42 FR 47840, 69 FR 53136). The channel within Unit FK16 and SP4 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with coal mining, silviculture-related activities, natural gas and oil exploration activities in headwater reaches, agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK17 and SP5: Powell River, Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia. Unit FK17 and SP5 includes approximately 153 rkm (95 rmi) of the Powell River from the U.S. 25E Bridge in Claiborne County, TN, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs) in Lee County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings, road easements, and a small portion that is adjacent to the Cedars SNAP. The Nature Conservancy also owns a small portion of adjacent property. The unit completely overlaps critical habitat for the Cumberlandian combshell, rough rabbitsfoot, purple bean, and oyster mussel, and the entire length of this unit has been designated as critical habitat for the slender chub and yellowfin madtom (42 FR 45526, 42 FR 47840, 69 FR 53136). The channel within Unit FK17 and SP5 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with coal mining, natural gas and oil exploration activities in headwater reaches, agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK18 and SP6: Nolichucky River, Cocke, Hamblen, and Greene Counties, Tennessee. Unit FK18 and SP6 includes approximately 52 rkm (32 rmi) of the Nolichucky River from rkm 14 (rmi 9), approximately 0.6 rkm (0.4 rmi) upstream of Enka Dam, where it divides Hamblen and Cocke Counties, TN, upstream to its confluence with Pigeon Creek, just upstream of the Highway 321 Bridge crossing, in Greene County, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. The fluted kidneyshell population is a result of a successful reintroduction program implemented by TWRA and other conservation partners. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings, road easements, and a small portion that is within Mullins Island Wildlife Management Area. A portion of this unit (8 rkm (5 rmi)) has been designated as a critical habitat for the oyster mussel and Cumberlandian combshell (69 FR 53136). The channel within Unit FK18 and SP6 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel and the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities, silviculture-related activities, rock mining, lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK19: Holston River, Knox, Grainger, and Jefferson Counties, Tennessee. Unit FK19 includes approximately 85 rkm (53 rmi) of the Holston River from its confluence with the French Broad River in Knox County, TN, upstream to the base of Cherokee Dam at rkm 83.7 (rmi 52.3) along the Grainger and Jefferson County, TN, line. The unit is within the Tennessee River system. This unit is considered unoccupied by the fluted kidneyshell and slabside pearlymussel, but within the species' historical ranges. Live fluted kidneyshell have not been collected in the Holston River since the early 1900s (Ortmann 1918, p. 614). As discussed below, we consider Unit FK19 essential for the conservation of the fluted kidneyshell, but not the slabside pearlymussel, and so it is designated as critical habitat only for the fluted kidneyshell. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The unit completely overlaps a designated nonessential experimental population for 15 mussels, 1 snail, and 5 fishes (72 FR 52434). We consider this unit essential for the conservation of the fluted kidneyshell due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. Although live fluted kidneyshell have not been collected in the Holston River since the early 1900s (Ortmann 1918, p. 614), the Tennessee Valley Authority (TVA) has improved conditions for aquatic species within this unit. Between 1988 and 1995, TVA implemented reservoir release improvements below Cherokee Dam on the Holston River. These improvements included the establishment of minimum flows and increasing the amount of dissolved oxygen in the tailwater below the reservoir (Scott et al. 1996, p. 21). The unit currently supports populations of three federally listed species (threatened snail darter and endangered pink mucket and sheepnose). In addition, other mussel species co-occur with these species along with a diverse fish fauna, including hosts for the fluted kidneyshell. These host fishes are bottom-dwelling species that are able to move into refugia of low flows during high discharges from the hydropower dam upstream. Therefore, the fluted kidneyshell glochidia may come into contact and infest the host fishes. The slabside pearlymussel and its host fishes are known from the Holston River drainage; however, hydropower operations make this habitat unsuitable for mid-water column fishes, such as the shiners that are hosts for the slabside pearlymussel (Layzer and Scott 2006, pp. 481, 488–9). Therefore, we are not designating Unit FK19 as critical habitat for the slabside pearlymussel at this time.

Unit FK20: French Broad River, Knox and Sevier Counties, Tennessee. Unit FK20 includes approximately 56 rkm (35 rmi) of the French Broad River from its confluence with the Holston River in Knox County, TN, upstream to the base of Douglas Dam at rkm 51.7 (rmi 32.3) in Sevier County, TN. The unit is within the Tennessee River system. This unit is considered unoccupied by the fluted kidneyshell and slabside pearlymussel, but within the species' historical ranges. Fluted kidneyshell are only known from archaeological records in the French Broad River (Parmalee 1988 in Layzer and Scott 2006, pp. 481–482). As discussed below, we consider Unit FK20 essential for the conservation of the fluted kidneyshell, but not the slabside pearlymussel, and so it is designated as critical habitat only for the fluted kidneyshell. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements and a small portion that is within Forks of the River Wildlife Management Area. The unit completely overlaps a NEP for 15 mussels, 1 snail, and 5 fishes (72 FR 52434). We consider this unit essential for the conservation of the fluted kidneyshell due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. Fluted kidneyshell are only known from archaeological records in the French Broad River (Parmalee 1988 in Layzer and Scott 2006, pp. 481–482). However, between 1987 and 1995, TVA implemented reservoir release improvements below Douglas Dam on the French Broad River. These improvements included the establishment of minimum flows and increasing the amount of dissolved oxygen in the tailwater below the reservoir (Scott et al. 1996, pp. 11–12), improving conditions for the fluted kidneyshell and other aquatic species. The unit does currently support populations of the federally threatened snail darter and endangered pink mucket. In addition, other mussel species co-occur with these species and a diverse fish fauna, including hosts for the fluted kidneyshell. These host fishes are bottom-dwelling species that are able to move into refugia of low flows during high discharges from the hydropower dam upstream. Therefore, the fluted kidneyshell glochidia may come into contact and infest the host fishes. The slabside pearlymussel and its host fishes are known from the French Broad River drainage; however, hydropower operations make this habitat unsuitable for mid-water column fishes, such as the shiners that are hosts for the slabside pearlymussel (Layzer and Scott 2006, pp. 481, 488–9). Therefore, we are not designating Unit FK20 as critical habitat for the slabside pearlymussel at this time.

Unit FK21 and SP7: Hiwassee River, Polk County, Tennessee. Unit FK21 and SP7 includes approximately 24 rkm (15 rmi) of the Hiwassee River from the Highway 315 Bridge crossing upstream to the Highway 68 Bridge crossing in Polk County, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell at the time of listing, but within the species' historical range. Fluted kidneyshell are only known from archaeological records in the Hiwassee River (Parmalee and Bogan 1998, p. 205). This unit is considered essential for the conservation of the fluted kidneyshell (see Criteria Used To Identify Critical Habitat above for our rationale). A portion of this unit is considered a ''cut-off'' reach, because most of the water flow bypasses the reach through a tunnel from Apalachia Dam to the Apalachia powerhouse for the production of electricity. This unit is located entirely on federal lands within the Cherokee National Forest (CNF). Land and resource management decisions and activities within the CNF are guided by CNF's LRMP (USFS 2004b, pp. 28–37, entire). The channel within Unit FK21 and SP7 has an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2). Diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with silviculture-related activities, nonpoint source pollution, water diversion through Apalachia tunnel, and potential canopy loss caused by infestations of the hemlock woolly adelgid. Another threat to the species and their habitat which may require special management of the PCEs is the potential for significant changes in the existing flow regime and water quality due to upstream impoundment. As discussed in the final listing rule published elsewhere in today's Federal Register under Summary of Factors Affecting the Species, ''Impoundments,'' mollusk declines below dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles below the dam.

Unit SP8: Sequatchie River, Marion, Sequatchie, and Bledsoe Counties, Tennessee. Unit SP8 includes approximately 151 rkm (94 rmi) of the Sequatchie River from the Highway 41, 64, 72, 2 Bridge crossing in Marion County, TN, upstream to the Ninemile Cross Road Bridge crossing in Bledsoe County, TN. The unit is within the Tennessee River system. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Unit SP8 has an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitat may require special management considerations or protection to address potential adverse effects caused by agricultural activities, coal mining, silvicultural activities, lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution arising from a wide variety of human activities.

Unit SP9: Paint Rock River, Madison, Marshall, and Jackson Counties, Alabama. Unit SP9 includes approximately 86 rkm (53 rmi) of the Paint Rock River from the Highway 431 Bridge crossing along the Madison and Marshall County line, AL, upstream to the confluence of Estill Fork and Hurricane Creek in Jackson County, AL. The unit includes approximately 11 rkm (7 rmi) of Larkin Fork from its confluence with the Paint Rock River upstream to its confluence with Bear Creek, in Jackson County, AL; approximately 13 rkm (8 rmi) of Estill Fork from its confluence with the Paint Rock River upstream to its confluence with Bull Run in Jackson County, AL; and approximately 16 rkm (10 rmi) of Hurricane Creek from its confluence with the Paint Rock River upstream to its confluence with Turkey Creek in Jackson County, AL. The unit is within the Tennessee River system and is critical habitat for the slabside pearlymussel. The unit is included in the geographical area occupied by the slabside pearlymussel at the time of listing. Approximately 6 rkm (4 rmi) of this unit is federally or State-owned and adjacent to the Fern Cave National Wildlife Refuge and Walls of Jericho State Management Area; the remainder is privately owned, including a small parcel owned by the Alabama Land Trust. A portion of this unit (80 rkm (50 rmi)) is critical habitat for the rabbitsfoot (78 FR 57076). The channel within Unit SP9 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitat may require special management considerations or protection to address potential adverse effects associated with agricultural activities, silvicultural activities, off-road vehicle use and other recreational activities, and nonpoint source pollution originating in headwater reaches.

Unit FK22 and SP10: Elk River, Limestone County, Alabama, and Giles, Lincoln, Franklin, and Moore Counties, Tennessee. Unit FK22 and SP10 includes approximately 164 rkm (102 rmi) of the Elk River from its inundation at Wheeler Lake in Limestone County, AL, upstream to its confluence with Farris Creek at the dividing line between Franklin and Moore Counties, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell, but within the species' historical range. Live fluted kidneyshell have not been collected in the Elk River since the late- 1960s (Isom et al. 1973, p. 440). The unit is considered essential for the conservation of the fluted kidneyshell (see Criteria Used To Identify Critical Habitat above for our rationale). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements and a small portion that is within TVA-owned lands near Wheeler Reservoir. Unit FK22 and SP10 has an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with hydropower generation from Tims Ford Dam, agriculture, nonpoint source pollution, and instream gravel mining. Another threat to the species and their habitat which may require special management of the PBFs is the potential for significant changes in the existing flow regime and water quality due to upstream impoundment. As discussed in the final listing rule published elsewhere in today's Federal Register under Summary of Factors Affecting the Species, ''Impoundments,'' mollusk declines below dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles below the dam.

Unit SP11: Bear Creek, Colbert County, Alabama, and Tishomingo County, Mississippi. Unit SP11 includes approximately 42 rkm (26 rmi) of Bear Creek from its inundation at Pickwick Lake at rkm 37 (rmi 23) in Colbert County, AL, upstream through Tishomingo County, MS, and ending at the Mississippi/ Alabama State line. The unit is within the Tennessee River system and is critical habitat for the slabside pearlymussel. This unit is included in the geographical area occupied by the slabside pearlymussel at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements, and that within Tishomingo State Park and the Natchez Trace Parkway. The unit completely overlaps critical habitat for the oyster mussel and Cumberlandian combshell (69 FR 53136), and overlaps with a portion (42 rkm (26 rmi)) of the critical habitat unit for the rabbitsfoot (78 FR 57076). The channel within Unit SP11 has an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitat may require special management considerations or protection to address potential adverse effects associated with releases from upstream impoundments, agriculture, and nonpoint source pollution originating in headwater reaches.

Unit FK23 and SP12: Duck River, Humphreys, Perry, Hickman, Maury, Marshall, and Bedford Counties, Tennessee. Unit FK23 and SP12 includes approximately 348 rkm (216 rmi) of the Duck River from its inundation at Kentucky Lake in Humphreys County, TN, upstream to its confluence with Flat Creek near Shelbyville in Bedford County, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. The fluted kidneyshell population is a result of a successful reintroduction program implemented by TWRA and other conservation partners, resulting in the recruitment of the species in the Duck River. Approximately 64 rkm (39 rmi) of this unit is federally or State-owned and adjacent to the Tennessee National Wildlife Refuge, Natchez Trace Parkway, Yanahli Wildlife Management Area, and Henry Horton State Park; the remainder is privately owned. A portion of this unit (74 rkm (46 rmi)) has been designated as a critical habitat for the oyster mussel and Cumberlandian combshell (69 FR 53136) and a portion of this unit (235 rkm (146 rmi)) is critical habitat for the rabbitsfoot (78 FR 57076). The channel within Unit FK23 and SP12 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities (livestock), water withdrawals, lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK24 and SP13: Buffalo River, Humphreys and Perry Counties, Tennessee. Unit FK24 and SP13 includes approximately 50 rkm (31 rmi) of the Buffalo River from its confluence with the Duck River in Humphreys County, TN, upstream to its confluence with Cane Creek in Perry

County, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell, but within the species' historical range. Live fluted kidneyshell have not been collected in the Buffalo River since the early 1920s (Ortmann 1924, p. 28). The unit is considered essential for the conservation of the fluted kidneyshell (see Criteria Used To Identify Critical Habitat above for our rationale). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Unit FK24 and SP13 has an abundance of riffle habitats (PCE 1) and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with agriculture, destabilized substrates, and nonpoint source pollution.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Colbert, Jackson, Limestone, Madison, and Marshall Counties, Alabama; Tishomingo County, Mississippi; Bedford, Bledsoe, Claiborne, Cocke, Franklin, Giles, Greene, Hamblen, Hancock, Hickman, Humphreys, Lincoln, Marion, Marshall, Maury, Moore, Perry, Polk, and Sequatchie Counties, Tennessee; and Bland, Lee, Russell, Scott, Smyth, Tazewell, Washington, and Wythe Counties, Virginia. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of slabside pearlymussel consist of five components:

(i) Riffle habitats within large, geomorphically stable stream channels (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand, gravel, and cobble with low to moderate amounts of fine sediment and containing flow refugia with low shear stress.

(iii) A natural hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species is found, and connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability for all life stages, and spawning habitat for native fishes.

(iv) Water quality with low levels of pollutants and including a natural temperature regime, pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams/liter), hardness, and turbidity necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of abundant fish hosts, which may include the popeye shiner, rosyface shiner, saffron shiner, silver shiner, telescope shiner, Tennessee shiner, whitetail shiner, white shiner, and eastern blacknose dace, necessary for recruitment of the slabside pearlymussel.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on October 28, 2013.

The occupied units designated as critical habitat for the fluted kidneyshell (17) will require some level of management to address the current and future threats to the PBFs of the species.

Special management considerations or protection will conserve the PBFs for this species. Management activities that could ameliorate threats on both Federal and non-Federal lands include, but are not limited to: Use of best management practices (BMPs) designed to reduce sedimentation, erosion, and stream bank alteration; moderation of surface and ground water withdrawals to maintain natural flow regimes; increase of stormwater management and reduction of stormwater flows into the systems; preservation of headwater streams; regulation of off-road vehicle use; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water.

Life History

Feeding Narrative

Adult: Larvae (glochidia) of freshwater mussels generally are parasitic on fish and display varying degrees of host specificity. No specific trophic studies have been conducted on this species. General literature claims that mussels are filter-feeders that remove phytoplankton from the water column. These assumptions are based on casual observations on mussels in situ and a few examinations of rectal contents. Baker (1928) speculated that detritus was the primary energy source. This has been substantiated by James (1987) and correlates well with observed microhabitat utilization. Being poikilothermic, activity levels would expectedly be reduced greatly during cold temperature months (NatureServe, 2015).

Reproduction Narrative

Adult: This species is a short-term, summer brooder (gravid females reported from May until August) with ectobranchous marsupia. Natural infections of glochidia have been found on popeye shiner (Notropis ariommus), Tennessee shiner (Notropis leuciodus), silver shiner (Notropis photogenis), rosyface shiner (Notropis rubellus), saffron shiner (Notropis rubricroceus), telescope shiner (Notropis telescopus) (Neves, 1991; Kitchell, 1985); as well as small mouth bass (Micropterus dolomieu) (Barnhart et al., 1995) (NatureServe, 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species occurs in moderate to high gradient riffles systems in creeks to large rivers. It is generally found at depths <1 m, moderate to swift current velocities, and substrates from coarse sand to heterogeneous assemblages of larger sized particles. The slabside pearlymussel is primarily a large creek to moderately-sized river species, inhabiting sand, fine gravel, and cobble substrates in relatively shallow riffles and shoals with moderate current (Parmalee and Bogan, 1998). This species requires flowing, well-oxygenated waters to thrive. This species is highly to moderately vulnerable, with a moderate environmental specificity. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). Primary constituent elements include geomorphically stable stream channels; stable substrates; and water quality with pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter (mg/L)) (USFWS, 2013).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is probably rather sessile with only limited movement through the substrate. Passive downstream movement may occur when mussels are displaced from the substrate during floods. Major dispersal occurs while glochids are encysted on their hosts. This species is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Declining (USFWS, 2021)

Number of Populations:

14 (USFWS, 2021)

Population Size:

2500 - 10,000 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

The remaining populations of the slabside pearlymussel are generally small and geographically isolated. The patchy distribution pattern of populations in short river reaches makes them much more susceptible to extirpation from single catastrophic events, such as toxic chemical spills. Such a spill that occurred in the upper Clinch River in 1998 killed thousands of mussel specimens of several species, including three federally listed species. Furthermore, this level of isolation makes natural repopulation of any extirpated population impossible without human intervention. With the completion of numerous main stem Tennessee River dams during primarily the first half of this century, the main stem population was soon extirpated, and the remaining populations isolated. Whereas small isolated tributary populations of imperiled short-lived species (e.g., most fishes) would have theoretically died out within a decade or so after impoundment, the long-lived slabside pearlymussel would potentially take decades to expire post impoundment (USFWS, 2003; 2010; Grobler et al., 2006). During historical times, the slabside pearlymussel was fairly widespread and common in many Cumberlandian Region streams based on collections made in the early 1900s. However, its decline in certain streams may have begun before European colonization. The presence of the slabside pearlymussel in several streams, particularly those in the middle Tennessee River system, is known only by records from aboriginal kitchen middens. We currently recognize 14 extant population segments; they are the: 1. Powell River (VA/TN; last record 2012), 2. Clinch River (VA/TN; last record 2020), 3. North Fork Holston River (VA; last record 2013), 4. Middle Fork Holston River (VA; last record 2018), 5. Little River (TN; discovered in 2014), 6. Nolichucky River (TN; last record 2010), 7. Little Pigeon River (TN; last record 2014), 8. Hiwassee River (TN; last record 2002), 9. Sequatchie River (TN; last record 2021), 10. Paint Rock River (AL; last record 2018), 11. Flint River (AL; last record 2015), 12. Elk River (TN/AL); last record 2021), 13. Bear Creek (AL/MS); last record 2020), and 14. Duck River (TN; last record 2020). The slabside pearlymussel is currently known from approximately 1,300 of 4,450 historically occupied rkm, representing over a 70 percent reduction in range. The final listing rule (Service 2013) identified this factor as the primary cause of the species' decline and cited impoundments, gravel and coal mining, sedimentation, water pollution, and stream channel alterations as major causes of habitat loss and degradation. The construction of dams within the range of the slabside pearlymussel has resulted in major and enduring effects to the species by isolating populations, altering the physical habitat, blocking upstream and downstream movement, and changing flow and temperature regimes. In recent years, some improvements have been made to improve riverine conditions. For example, operational changes were initiated at the Tims Ford Dam on the Elk River by TVA in 2006 to improve habitat below the dam by altering the discharge to better mimic a natural flow and temperature regime (TVA 2008). Although these improvements have occurred, this threat is still a primary driver to species declines and still impacts all populations and historical reaches throughout its range. (USFWS, 2021)

Threats and Stressors

Stressor: Altered temperature regimes (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Natural temperature regimes can be altered by impoundments, water releases from dams, industrial and municipal effluents, and changes in riparian habitat. Critical thermal limits

for survival and normal functioning of many mussel species are unknown. High temperatures can reduce dissolved oxygen concentrations in the water, which slows growth, reduces glycogen stores, impairs respiration, and may inhibit reproduction. Low temperatures can significantly delay or prevent metamorphosis. Water temperature increases have been documented to shorten the period of glochidial encystment, reduce the speed in which they turn upright, increase oxygen consumption, and slow burrowing and movement responses (USFWS, 2013).

Stressor: Chemical contaminants (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Chemical contaminants are ubiquitous throughout the environment and are considered a major threat in the decline of mussel species. Chemicals enter the environment through both point and nonpoint discharges, including spills, stormwater infrastructure, industrial sources, municipal effluents, and agricultural runoff. These sources contribute organic compounds, heavy metals, pesticides, pharmaceuticals, and a wide variety of newly emerging contaminants to the aquatic environment. These waterborne chemicals alter mussel behavior and influence successful attachment of glochidia on fish hosts, and therefore, may have population-level implications for the slabside pearlymussel. It is likely that chemical contaminants have contributed to declining slabside pearlymussel populations and will likely continue to be a threat in the future. These threats result from spills that are immediately lethal to these species, as well as chronic contaminant exposure, which results in death, reduced growth, or reduced reproduction of slabside pearlymussel (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: There is a growing concern that climate change may lead to increased frequency of severe storms and droughts. Specific effects of climate change to mussels, their habitats, and their fish hosts could include changes in stream temperature regimes and changes in the timing and levels of precipitation, causing more frequent and severe floods and droughts. Increases in temperature and reductions in flow can also lower dissolved oxygen levels in interstitial habitats, which can be lethal to juveniles . Even small increases in temperature can cause reductions in the survival of freshwater mussel glochidia and juveniles, and temperatures currently encountered in the temperate United States during summers are close to or above the upper thermal tolerances of early life stages of freshwater mussels . Effects to mussel populations from these environmental changes could include reduced abundance and biomass, altered species composition, and reduced host fish availability (USFWS, 2013).

Stressor: Habitat destruction and modification (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Habitat loss and degradation negatively impact the slabside pearlymussel. Severe degradation from impoundments, gravel and coal mining, oil and natural gas development, sedimentation, chemical contaminants, and stream channel alterations threaten the stream habitat and water quality on which these species depend. Contaminants associated with coal

mining (metals, other dissolved solids), municipal effluents (bacteria, nutrients, pharmaceuticals), and agriculture (fertilizers, pesticides, herbicides, and animal waste) cause degradation of water quality and habitats through increased acidity and conductivity, instream oxygen deficiencies, excess nutrification, and excessive algal growths (USFWS, 2013).

Stressor: Nonindigenous species (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The Asian clam (Corbicula fluminea) has been introduced to the Cumberland and Tennessee River drainages and may be adversely affecting the slabside pearlymussel, particularly juveniles, through direct competition for space and resources. Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles, and may actively disturb sediments, reducing habitable space for juvenile native mussels or displacing them downstream (USFWS, 2013).

Stressor: Population fragmentation and isolation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Population isolation prohibits the natural interchange of genetic material between populations, and small population size reduces the reservoir of genetic diversity within populations, which can lead to inbreeding depression. Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction. It is likely that some populations of the slabside pearlymussel are below the effective population size required to maintain long-term genetic and population viability (USFWS, 2013).

Stressor: Stochastic events (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The remaining populations of the fluted kidneyshell and slabside pearlymussel are generally small and geographically isolated. The patchy distribution pattern of populations in short river reaches makes them much more susceptible to extirpation from single catastrophic events, such as toxic chemical spills (USFWS, 2013).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Fluted Kidneyshell and Slabside Pearlymussel. Final rule. 78 FR 59555 - 59620 (September 26, 2013).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2013. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Fluted Kidneyshell and Slabside Pearlymussel

Final Rule. 78 Federal Register 187. Pages 59555 - 59620.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2021. Slabside Pearlymussel (Pleuronaia dolabelloides). 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Atlanta Regional Office Tennessee Ecological Services Field Office Cookeville, Tennessee. 20 pp.

USFWS. 2013. Endangered Species Status for the Fluted Kidneyshell and Slabside Pearlymussel

Final Rule. 78 Federal Register 187. September 26, 2013. Pages 59269 - 59287.

SPECIES ACCOUNT: *Popenaias popei* (Texas hornshell)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered; Southwest Region (R2) (USFWS, 2016)

Physical Description

Shells of Texas hornshell are trapezoidal, compressed, gently rounded posteriorly, and generally dark brown to dark green (Howells 1996a, p. 93). Maximum length has been reported as 116 millimeters (mm) (4.5 inches (in.)) (Howells 1996a, p. 93). The Texas hornshell is a medium sized freshwater mussel with a dark brown to green, elongate, laterally compressed shell reac hing lengths of over 110 millimeters (mm) (Service 2018). It is native to the Rio Grande drainage in Texas , New Mexico, and northern Mexico. Adult and juvenile Texas hornshell occur in medium to large rivers , gene rally in crevices, undercuts, riverbanks, travertine shelves, and under large boulders that contain suitable amounts of small grained substrate, such as clay, silt, and/or sand. Juveniles likely inhabit i nterstitial s paces within t rapped substrate and adults typically anchor in suitable substrate (Service 2018). Areas within crevices, undercuts, riverbank, travertine shelves, and under boulder provide flow refugia from large flood events that occur regularly within the Rio Grande basin. However, the Devils River population is an exception; this population is typically found within gravel beds at the head ota. riffles and rapids (Service 2018). Texas hornshell, like most freshwater mussels, has a complex life history, which requires the use of water column and host fish for successful reproduction and metamorphosis into juvenile mussels. Their longevity is unknown; however, a mark and recapture effort conducted in 1997 and again 15 years later, indicates that the species is capable of living 15 or more years (Service 2018) (USFWS, 2018).

Taxonomy

The Texas hornshell (Popenaias popeii) is a member of the freshwater mussel family Unionidae. It was originally described as Unio popeii by Lea in 1857, but was later placed in the genus Elliptio by Ortmann (1912) and afterward given its own subgenus within the genus Elliptio (Frierson 1927). Subsequently, Heard and Guckert (1970) elevated Popenaias to genus and created a new subfamily, Popenaiadinae, for the genera Cyrtonaias and Popenaias. Popenaiadinae was dropped on the basis that its diagnostic criteria represented species-specific rather than phylogenetically significant characters (Heard 1974). Currently, Texas hornshell is classified in the unionid subfamily Ambleminae (Campbell et al. 2005, p. 144) and is considered a valid taxon by the scientific community (Turgeon et al. 1998, p. 36). Data collected and analyzed under an ongoing genetics study including individuals from Texas and New Mexico reveal a single species across all populations (Hoeh 2009).

Historical Range

Historically, Texas hornshell is known to have occurred in the lower portion of the Pecos River in New Mexico, in the Rio Grande from San Francisco Creek (in the Big Bend reach, Brewster County, Texas) downstream throughout the Lower Rio Grande (Brownsville, Texas), in major tributaries of the Rio Grande in Texas, and southward to the Río Pánuco drainage of San Luis Potosí, México (Metcalf 1982; Taylor 1983; Neck and Metcalf 1988; Howells et al. 1996). In New Mexico, this species was common in the lower Pecos River from North Spring River, Roswell, Chaves County (Cockerell 1902) south to Texas, including the Black and Delaware Rivers in Eddy County (Taylor 1983; NMDGF 2007). Live specimens were taken from the lower Pecos River near

Carlsbad, New Mexico, as late as 1937 (Metcalf 1982). Umbonal shell fragments of fossilized Texas hornshell were collected from the Pecos River on the Salt Creek Wilderness of the Bitter Lake National Wildlife Refuge (Chaves County) and the Delaware River (Eddy County) in 1996 (Lang 2001). Texas historically held an abundant and diverse assemblage of freshwater mussels, with 52 species (of the over 300 native taxa in the United States) present in the waters of the State (Howells et al. 1996, p. 1; Howells et al. 1997). Dramatic declines have been documented in the past 2 decades, to a level of such significance that many rivers and streams no longer support any native freshwater mussel populations (Howells et al. 1997). Early records show Texas hornshell in the Pecos River, Ward County, Texas (Strecker 1931) and near the Rio Grande confluence in Val Verde County, Texas (Metcalf 1982). In the Rio Grande in Texas, collections indicate the species historically occurred from San Francisco Creek in the Big Bend area, Brewster County, downstream to Brownsville, near the Gulf of America (Howells et al. 1996, p. 93). Historical collections also confirm the presence of Texas hornshell in the Devils River and Las Moras Creek, tributaries to the Rio Grande (Howells et al. 1996, p. 93). Live specimens from these areas in Texas were reported by Strecker (1931). Historical collections in Mexico are from the Río Salado (type locality) and two disjunct drainages, Ríos Pánuco and Valles (in the state of San Luis Potosí), some 805 kilometers (km) (500 miles (mi)) south of the Rio Grande basin (Hinkley 1907; Ortmann 1912). Unfortunately, scientific understanding of freshwater mussels located in Mexico is especially poor and aspects of classification, biology, and distribution remain confused. Therefore, the historical distribution of Texas hornshell in Mexico cannot be fully determined.

Current Range

The Texas hornshell has declined notably throughout its historical range. The species is confirmed to be extant in the Black River in New Mexico and the Devils River and Rio Grande in Texas (Howells and Ansley 1999; Howells 2001; Howells 2004; Strenth et al. 2004; Burlakova and Karatayev 2008, 2011, p. 5; Miller 2008, 2009). The Texas hornshell is restricted to about 12 percent of its known historical range in New Mexico (Lang 2009) and represents the last remaining native freshwater mussel in New Mexico, as all other mussels (seven species) considered native in the State have been extirpated (Metcalf 1982, Lang and Mehlhop 1996). Since 1996, a population of Texas hornshell has been confirmed in the Black River (western tributary of the Pecos River), New Mexico, from Black River Village downstream to the U.S. Highway 285 bridge crossing, in Eddy County (Lang 2001). This population is considered isolated from the Texas populations as they are hydrologically separated by large dams and reservoirs and numerous small diversions. Prior to 1996, live Texas hornshell had not been reported in New Mexico since the 1930s (Metcalf 1982). The population occurs in approximately 14 km (8.7 mi) of the Black River between two low-head dams (Lang 2001). This section of the Black River has permanency of flow, adequate water quality, and suitable substrates that provide habitat conditions for the persistence of this relict population. In the Rio Grande, Texas hornshell is known from downstream of Big Bend National Park and near Laredo, in Webb County, Texas (Burlakova and Karatayev 2011, p. 1). Freshwater mussel surveys were initiated in the lower Pecos River in Texas in 1995 and monitoring surveys are ongoing sporadically, but to date have not located any shells of Texas hornshell. Despite numerous collection efforts in the 1990s, no evidence of living freshwater mussels was documented in these areas (Howells 1994, 1996a, 1996b, 1997, 1998, 1999, 2001, 2003, 2004; Howells et al. 1996; Howells and Ansley 1999). The distribution of the species in Texas and Mexico was reviewed in Strenth et al. (2004). Dead shells of Texas hornshell were recently located in the Río Sabinas of northern Chihuahua, Mexico; and from two tributaries of the Colorado River in central-west Texas (Llano River, Llano County and

South Concho River, Tom Green County). However, no evidence was found indicating there are extant populations of Texas hornshell in these locations (Strenth et al. 2004).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Texas hornshell have separate sexes, and spawning occurs from January through September in the Black River in New Mexico (Lang 2001; Smith et al. 2003). Females produce ova that are held in a modified gill chamber. Ova are fertilized by sperm, which are released into the water column by males and then taken in through the incurrent siphon of the female. Developing zygotes are held in brood pouches of the gills (marsupia) for 4 to 6 weeks (Smith et al. 2003). Female Texas hornshell release larvae, called glochidia, in a sticky mucous mass or string, called a conglutinate, between May and July each year (Smith et al. 2003). Glochidia are obligate parasites on fish and attach to the gills, fins, or head of appropriate host species where they encyst and feed off of the hosts body fluids. Laboratory studies have indicated that P. popeii is a host generalist (e.g., Lang 2001, 2004, 2009; Levine et al. In Review, p. 6). However, three species of fish the river carpsucker (Carpoiodes carpio), gray redhorse (Moxostoma congestum), and red shiner (Cyprinella lutrensis) represented 80 percent of all individual fishes infested with Texas hornshell glochidia and carried over 99 percent of estimated glochidiain a recent study (Lang 2010, p. 19). Completely metamorphosed juveniles are recruited into the free-living benthic-dwelling community once released from the host fish (Trdan and Hoeh 1982, p. 381). Large, heavy-shelled riverine species, like Texas hornshell, tend to have longer life spans, commonly exceeding 20 years (Anthony et al. 2001, p. 1354).

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Based on our current knowledge of habitat and life history characteristics of the Texas hornshell, important characteristics of habitat appear to include: 1) freeflowing streams with undercut riverbanks, crevices, shelves, or large boulders that provide the flow refuges preferred by the species, and 2) water with no or low levels of pollutants.Texas hornshell are found where small-grained substrata (clays, silts, sands, and gravel) collect in undercut riverbanks, crevices, shelves, and at the base of large boulders (Lang 2006, p. 8). Within these macrohabitat types, Texas hornshell occur singly or aggregated in shallow water microhabitats that serve as flow refugia (Strayer 1999) during large volume discharge periods associated with annual precipitation events (Lang 2001). These macrohabitat types are found in the Black River, New Mexico; a shallow, narrow stream that runs over travertine bedrock. In the Rio Grande, they are found under large boulders or beneath limestone ledges where clay seams provide a stable substrate (Burlakova and Karatayev, 2011 p. 2).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Rio Grande River (Laredo) population seems to be thriving, the Black River population is stable, while the rest are declining.

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

6 (USFWS, 2023)

Population Size:

greater than 8700

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

In 1998, 32 sites along approximately 161 km (100 mi) of the Rio Grande downstream of Big Bend National Park in Texas and Mexico were surveyed by the Texas Parks and Wildlife Department (TPWD) (Howells and Ansley 1999; Howells 2001). Although no live Texas hornshell were observed, three of five valves collected were of recently dead specimens. In addition, Big Bend National Park began conducting searches for mussels starting in 2005 and has found 48 dead Texas hornshells, many of them recently dead, in the Rio Grande in Big Bend National Park, and in the lower canyons area of the Rio Grande Wild and Scenic River downstream of the Park (Skiles 2008). This information indicates there are likely extant populations in this reach of the Rio Grande. Extensive collections in the Rio Grande Basin in Texas and in the Rio Conchos Basin in Mexico by TPWD provided no evidence of any other extant populations (Howells 1994, 1995, 1996a, 1996b, 1997, 1998, 1999; Howells et al. 1997). However, in March 2008, two live Texas hornshell were discovered in the Devils River and one in the Rio Grande in the Rio Grande Wild and Scenic River segment downstream of Big Bend National Park (Miller 2008; Burlakova and Karatayev 2008). In March 2011, one live individual was found in a survey of five sites in the Devils River (Burlakova and Karatayev 2011, p. 1), and a large population was discovered in the Rio Grande near Laredo, in Webb County, Texas. Using mark-recapture techniques and extrapolation over the area inhabited by the species, this population is estimated to contain over 8,700 individuals in multiple age classes and is the largest Texas hornshell population known (Burlakova and Karatayev 2011, p. 2). In the Black River, Levine (2009) analyzed 10 years of mark-recapture data and reported that this population appeared stable with active recruitment of juvenile mussels into the breeding population, exhibited variable annual growth increments (0.1 to 12.4 mm (0.0039 to 0.49 in)) between years, and showed an inverse relationship between survival and discharge with survivorship varying from 60 to 90 percent among years (Lang 2009). However, at one monitoring location significant population declines have been observed and no Texas hornshell have been collected since 2002. The decline is attributed to changes in physical habitat in the river channel caused by large flood events in 2000 that scoured the river bed and eliminated the mussels (Lang 2004). Intensive searches by the New Mexico Department of Game and Fish (NMDGF) in other portions of the Black River and nearby locations in the Delaware River and Pecos River have not revealed additional populations in this region (Lang 2001). Texas Hornshell is a unionid freshwater mussel with 6 extant, known populations. Populations are located in the Black River (New Mexico), Devils River (Texas), Pecos River (Texas), Rio Grande River – Lower Canyons (Texas), Rio Grande River – Laredo (Texas), and Rio San Diego, Mexico. Host fishes of Texas Hornshell include River Carpsucker, Gray Redhorse, and Red Shiner. Recent surveys have been conducted on the Texas Hornshell populations with recruitment being observed in the Black River, Devils River, Rio Grande River – Laredo, and Rio Grande River – Lower Canyons populations, and a new population discovered in Rio San Diego, Mexico (USFWS, 2023).

Threats and Stressors

Stressor: Water Impoundment
Exposure:
Response:
Consequence:
Narrative: Impoundments result in the dramatic modification of riffle and shoal habitats, and the resulting loss of mussels, especially in larger rivers. Dams interrupt most of a river's ecological processes by modifying flood pulses; controlling impounded water elevations; altering water flow, sediments, nutrients, and energy inputs and outputs; increasing depth; decreasing habitat heterogeneity; and decreasing stability due to subsequent sedimentation (Williams et al. 1992; Collier et al. 1996). The reproductive process of riverine mussels is generally disrupted by impoundments making the Texas hornshell unable to successfully reproduce and recruit under reservoir conditions or in tailwater habitats below dams and diversions. In addition, dams can seriously alter downstream water quality and riverine habitat (Collier et al. 1996), and negatively impact tailwater mussel populations. These changes include thermal alterations immediately below dams; changes in channel characteristics, habitat availability, and flow regime; daily discharge fluctuations; increased silt loads; altered host fish communities; and blocking migration patterns of host fishes.

Stressor: Water Diversion
Exposure:
Response:
Consequence:
Narrative: Human consumption of river water for agricultural irrigation and municipal use has also contributed to the degraded state of the aquatic ecosystems that no longer support Texas hornshell populations within the species historical range (Howells 2001). For example, in the upper watershed of the Rio Grande in New Mexico, flows have severely declined, often to the point of ceasing to flow during the irrigation season, resulting in ecological changes that severely limit native fauna persistence. Although this portion of the Rio Grande is not within the Texas hornshells historical range, groundwater withdrawals and surface water diversions in this part of the river affect the amount of water that reaches downstream habitats for the species. Increased

surface water diversions for municipal use in Las Cruces, New Mexico, and El Paso, Texas, will likely lead to less water for instream flows in the Rio Grande below El Paso, within the range of Texas hornshell.

Stressor: Alterations to Channel Morphology
Exposure:
Response:
Consequence:
Narrative: The channel morphology and flow regimes of the Rio Grande and Pecos River have been severely modified over the past century for flood control, water supply, and border maintenance through channelization, levee construction, destruction of native riparian vegetation, dredging, water diversion, and groundwater pumping (Howells 2001; NMDGF 2007). The invasion of the exotic riparian salt cedar (Tamarisk spp.), along with levees, have fortified the river banks. Flood control dams upstream have curtailed the annual peak flows and resulted in sediment rich, narrow river channels that no longer interact with the floodplain and do not provide natural riverine processes to support native biotic communities, including mussels such as the Texas hornshell (Layzer et al. 1993).

Stressor: Water Quality
Exposure:
Response:
Consequence:
Narrative: The release of pollutants into streams from point and nonpoint sources have immediate impacts on water quality conditions and may make environments unsuitable for habitation by mussels. In addition, Regional groundwater depletion can cause losses in stream flows that result in higher concentrations of pollutants and pollution can also arise from groundwater contaminants (Hennighausen 1969; Metcalf 1982; Quarles 1983; Taylor 1983; NMDGF 1988; Williams et al. 1993; Neves et al. 1997). Much of the riverine habitat within the historical range of Texas hornshell has experienced tremendous increases in salinity levels as a result of agricultural returns to the rivers (Howells 2001). Recent studies indicate that Texas hornshell show behavioral signs of physiological stress, followed by death, at a salinity of 7.0 parts per thousand (ppt). Within the occupied area of the Black River, salinity is about 0.9 ppt, but increases significantly downstream of the Carlsbad Irrigation District Dam near the confluence with the Pecos River to 2.8 ppt. Additionally, salinity levels in the Pecos River downstream of the Black River confluence range from 6.0-7.0 ppt (Lang 2001). Oil and gas industry operations (exploration, transfer, storage, and refining) are ongoing in the Black River basin and lower Pecos River valley of New Mexico and Texas. Such extraction activities are known to contaminate ground- and surface-waters (Jercinovic 1982, 1984; Longmire 1983; Boyer 1986; Rail 1989; Martinez et al. 1998), and represent a current threat to extant Texas hornshell populations (Eisler 1987; Havlik and Marking 1987, p. 11; Green and Trett 1989; Neves et al. 1997). Contaminants contained in point and nonpoint discharges can degrade water and substrate quality and adversely impact mussel populations. The effects are especially profound on juvenile mussels, which can readily uptake common contaminants such as ammonia and chlorine. Glochidia also appear to be very sensitive to certain toxicants, such as heavy metals. Even at low levels, certain heavy metals, such as copper, may inhibit glochidial attachment to fish hosts (Havlik and Marking 1987).

Stressor: Increased siltation and sedimentation

Exposure:
Response:
Consequence:
Narrative: Siltation and general sedimentation runoff have been implicated in the decline of stream mussel populations across the United States. Scouring in upstream areas often results in excessive deposition of silt downstream, infilling larger substrates and eliminating mussel habitats. Sources of silt and sediment include overgrazing, which began in the mid-1800s; removal of terrestrial plants and replacement with nonnative vegetation; complete clearing of riparian vegetation for agricultural, silvicultural, or other purposes; poorly designed and executed highways and bridges; and construction, mining, and other practices that allow exposed earth to enter streams (Howells 2001). Specific impacts on mussels from silt and sediments include clogged gills, which reduce feeding and respiratory efficiency, impair reproductive activity, disrupt metabolic processes, reduce growth rates; substrate instability; and the physical smothering of mussels under a blanket of silt (Houp 1993). Cumulative impacts of certain land-use practices (e.g., removal of native vegetation; prolonged overgrazing; nonpoint source runoff pollution of sediments, toxic chemicals, and hydrocarbons) within the watershed of the Black River have increased erosion and sedimentation in the river, exacerbated drainage basin entrenchment, increased pulse-discharge of pollutants into the system, and altered stream channel morphology and substrate composition (Lang 2001). These environmental changes have profound effects on the long-term viability of mollusk populations, overall health of aquatic ecosystems, and stability of low flow habitat typically colonized by Texas hornshell (Fuller 1974; Neves et al. 1997; Strayer 1999; NMDGF 2007). Pulse discharge of large storm flows in the Black River represent a primary cause of natural mortality of localized populations of Texas hornshell (Lang 2006). Large pulse discharges scour streambeds and appear to dislodge Texas hornshell from their habitats (Lang 2009).

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Climate change could be another cause of threats to water quantity and habitat maintenance for this aquatic species. The potential effects of future climate change could reduce overall water availability in New Mexico, Texas, and northern Mexico and compound the threat of declining flows. Modeling efforts evaluating climate change in Texas have only recently been initiated (for example, CH2M HILL 2008; Jackson 2008; Mace and Wade 2008). As with many areas of North America, the range of the Texas hornshell is projected to experience an overall warming trend over the next 50 to 100 years (Texas Water Development Board 2008). Although precipitation models vary substantially, with some even predicting increased precipitation annually, a consensus is emerging that evaporation rates are likely to increase significantly (CH2M HILL 2008; Jackson 2008). Many models are also predicting that seasonal variability in flow rates is likely to increase with more precipitation occurring in the wet seasons and more extended dry periods (CH2M HILL 2008, Jackson 2008, Mace and Wade 2008). A greater likelihood for more extreme droughts was identified as a potential impact to water resources (CH2M HILL 2008). All climate change modeling has inherently large uncertainties due to the incorporation of many variables that are difficult, if not impossible, to accurately predict (Jackson 2008; Texas Water Development Board 2008). As a result, it is unknown how much effect future climate change may have on the aquatic resources that serve as habitat for the Texas hornshell. If climate trends result in increased drought, then it could exacerbate declining flows for the

hornshell.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: Under the Wildlife Conservation Act, the State of New Mexico has listed the Texas hornshell as an endangered species since 1983. Protection under New Mexicos Wildlife Conservation Act is limited to take (harass, hunt, capture, or kill any wildlife, or attempt to do so), with no regulatory protection of occupied or potential habitats. The recovery plan for Texas hornshell issued by the State of New Mexico (NMDGF 2007, pp. 1-66) does not provide any additional regulatory mechanisms, but it is expected to improve the status of the species as it is implemented. Additionally, the Texas hornshell is considered a Species of Greatest Conservation Need in the New Mexico Comprehensive Wildlife Conservation Strategy (NMDGF 2006). The State of Texas listed the Texas hornshell as a threatened species in 2009. Section 68.002 of the Texas Parks and Wildlife (TPW) Code and Section 65.171 of the Texas Administrative Code prohibits the direct take of a threatened species, except under issuance of a scientific collecting permit. Enforcement of this permit requirement is difficult. Take is defined in Section 1.101(5) of the TPW Code as collect, hook, hunt, net, shoot, or snare, by any means or device, and includes an attempt to take or to pursue in order to take. However, this law does not provide any protection for Texas hornshell habitat, nor would it protect it from the proposed low-water diversion dam on the Rio Grande. Moreover, there are no statutory requirements under the jurisdiction of the State of Texas that serve as an effective regulatory mechanism for reducing or eliminating the threats that may adversely affect Texas hornshell or its habitat, nor are there any requirements under the Texas State statutes to develop a recovery plan that will restore and protect existing habitat for the species. Therefore, the species does not have a recovery plan, conservation plan, or conservation agreement in Texas. Texas has established 28 no-harvest mussel sanctuaries throughout the State (Howells et al. 1997). However, none occur within the Rio Grande or Pecos River basins. In December 2008, the U.S. Fish and Wildlife Service designated a 10(j) nonessential experimental population area for the Rio Grande silvery minnow in the Big Bend area of Texas. Because the Rio Grande silvery minnow will be treated as a threatened species within Big Bend National Park and the Rio Grande Wild and Scenic River, and will thus receive some protections under section 7 of the Endangered Species Act, this may provide some tangential regulatory protection for Texas hornshell where it shares riverine habitat with the minnow. There are no other listed fish species in this section of the Rio Grande. Based on our evaluation, we conclude that protections from existing regulatory mechanisms are not adequate to limit or alleviate the threats to the Texas hornshell.

Recovery

Reclassification Criteria:
Recovery Priority Number: 8 (USFWS, 2018).

(1) Through protection7 of existing stream populations, successful establishment of reintroduced stream populations, and/or the discovery of additional stream populations, at least six stream populations exist: five extant stream populations (three high resiliency and two moderate resiliency) in separate GMUs (Lower Canyons-Rio Grande, LaredoRio Grande, Devils River, Black River, and Rio San Diego) and one additional stream population in moderate

resiliency within its historical distribution and associated GMUs (Lower Pecos River, Delaware River, or Las Moras Creek) (USFWS, 2022).

(2) Each stream population in Criterion 1 exhibits evidence of recruitment, continued persistence, and positive or stable population trends (as evidenced by population size measured with sufficient precision to detect change of ±25 percent) for at least 15 years. In addition, unaided recruitment equals or exceeds mortality over a projected 45-year span, which is the expected minimum time to complete 3 generations (USFWS, 2022).

(3) Adequate flows in streams supporting both THS and its host fishes within at least six stream populations, one per GMU, have been ensured through state and local groundwater management plans, water conservation plans, drought contingency plans, regulations, or equivalent binding documents (USFWS, 2022).

(4) Flows from dam releases are managed so that scouring events are minimized or eliminated and allow for cleansing flows to maintain suitable THS and host fishes habitats (USFWS, 2022).

(5) Habitats necessary for THS and host fishes occupation are maintained or restored throughout at least six stream populations, one per GMU (USFWS, 2022).

(6) Protection of surface and ground water quality is ensured in at least six stream populations, one per GMU, by demonstrated compliance with water quality standards and implementation of water quality controls (USFWS, 2022).

(7) Hazardous material impacts are reduced or minimized in at least six stream populations, one per GMU, by demonstrating the development and implementation of a hazardous spill plan (USFWS, 2022)

(8) All planned and existing municipal discharges located within at least six stream populations, one per GMU, meet water quality standards protective of THS and its host fishes (USFWS, 2022).

(9) Excessive sedimentation is reduced by proper land management and erosion control measures within watersheds of at least six stream populations, one per GMU (USFWS, 2022).

(10) Connectivity is increased by incorporating fish passages and/or removal of anthropogenic barriers within at least six stream populations, one per GMU, to allow for the free movement of all life-stages of THS host fishes (USFWS, 2022).

Delisting Criteria:
(11) All downlisting criteria have been met and sustained, within at least seven stream populations (four with high resiliency and three with moderate to high resiliency), one per GMU, and have remained stable or increasing for an additional projected 45-year span (three additional generations, as described in the Recovery Strategy section); this is a total of at least 90 years (six generations) (USFWS, 2022).

Recovery Actions:
- The Texas hornshell is listed as endangered in New Mexico, threatened in Texas, and is a high priority species in the Wildlife Action Plans of New Mexico and Texas (TPWD 2005;

NMDGF 2006). NMDGF has ongoing studies in the Black River for Texas hornshell, including determination of ecological fish hosts, observing life history parameters, survivability of juveniles, monitoring habitat, and analyzing population dynamics (Lang 2006, Lang 2009). NMDGF has formed a State recovery team for this species and completed the Texas Hornshell Recovery Plan (Recovery Plan) for the population in New Mexico in August 2007 (Carman 2007). The Recovery Plan provides information about necessary conservation efforts to remove the need to list the species in New Mexico. The Recovery Plan does not include populations outside of New Mexico. NMDGF is leading the following ongoing efforts related to implementation of the Recovery Plan. The Bureau of Land Management (BLM) recently published a draft Environmental Assessment for the reintroduction of the Texas hornshell to the Delaware River (BLM 2013, entire). Reintroduction of the hornshell and a host fish species, the gray redhorse, is likely to occur in spring 2013. Big Bend National Park began conducting searches for mussels starting in 2005 and plans to continue searches as funding allows in the Rio Grande in Big Bend National Park and in the lower canyons area of the Rio Grande Wild and Scenic River downstream of the Park (Skiles 2008). In addition, TPWD has established a volunteer mussel watch program for interested individuals to report mussel shell collections and monitor some known populations in the State of Texas. The Service is currently placing new focus on the aquatic conservation of the Big Bend reach of the Rio Grande due to our efforts to reestablish the Rio Grande silvery minnow there. We are working on forming a collaborative group with our Federal, State, private, and nongovernmental partners in Texas to plan and accomplish riparian and aquatic ecosystem restoration projects. This effort will result in additional conservation measures for the river that could benefit Texas hornshell.

- Development of a Candidate Conservation Agreement with Assurances with private landowners;
- Working with New Mexico Environment Department to strengthen water quality requirements in the Black River and nominate it for Outstanding National Resource Water;
- Funding (along with the Natural Resources Conservation Service) private landowners for habitat protection. NMDGF has contracts with three New Mexico landowners to fence lands to prevent illegal trespass and dumping, which introduces toxic substances into the Black River;
- Funding the Albuquerque BioPark for captive rearing investigations for Texas hornshell. Appropriate habitat in the captive containers has been established and hornshells were taken from the wild and brought to the BioPark in the summers of 2008 and 2010;
- Continuing research on host fish relationships;
- Genetics research on the species (Carman 2008);
- Reintroduction of the Texas hornshell into the Delaware River, in cooperation with the Bureau of Land Management and the Service.
- Brief Action Plan: 1. Maintain suitable habitat to support viable populations by identifying river reaches that support high native aquatic biodiversity and Texas hornshell. 2. Minimize adverse effects to habitat and populations from threats by: (1) encouraging municipal and industrial compliance with current water quality discharge limits; (2) encouraging the use of effective silt and sediment runoff control from all activities within the river basins; (3) encouraging the development and implementation of adequate Streamside Management Zones along aquatic systems within identified critical habitat; (4) encouraging dam operation and water diversions to maintain base flows high enough to prevent excess sediment buildup in identified habitats; (5) working with stakeholders to implement water

management strategies to aid in Texas hornshell and fish host reproduction during the spawning season; and (6) working with the Service's Fisheries and Partners for Wildlife Programs, TPW D, New Mexico Department of Game and Fish (NMDGF), and others to determine what road crossing designs best allow for water and fish passage and are stable in the arid environments. 3. Work with stakeholders and partners to: (1) establish instream flow standards that support Texas hornshell and fish host needs; and (2) build upon current best management practices (BMPs) to improve water quality from wastewater treatment plant and industrial effluents. 4. Survey and monitor status of species by: (1) conducting surveys in remote areas of the Texas hornshell's historic range to determine presence and status; and (2) establishing long-term monitoring sites of known populations. 5. Conduct research in areas that will inform conservation of the species by: (1) determining contaminant sensitivity and work with Texas Commission on Environmental Quality (TCEQ) and the Environmental Protection Agency (EPA) to ensure water quality standards and classifications address the species needs; (2) looking into detailed physi al and molecular genetics analysis in new populations; (3) studying Texas hornshell life history to better understand food habits, age and growth, and mortality factors; (4) determining the minimum flow requirements; (5) determining population size and genetic make-up necessary for reintroduced populations to be self-sustaining in the Delaware River or other drainages. 6. Restore habitat and populations by: (1) working with stakeholders to remove existing fish migration barriers (including impound ments); (2) working with stakeholders to implement groundwater and surface water conservation strategies to maximize surface water flows; (3) work with private land owners, States, local government, and Federal partners to encourage land and water stewardship. 7. Education and outreach by: (1) working with State and Federal agencies, tribes, and private organizations to promote land and water stewardship; (2) developing programs and materials to inform the public on the need and benefits of aquatic ecosystem management; (3) reviewing management, monitoring strategies, and apply adaptive management; (4) identifying captive propagation requirements and develop a protocol for large-scale captive breeding and augmentation. Include a genetics management plan and locate a suitable location to maintain a captive population; and (5) working with partners to develop a protocol for release of captive bred individuals into occupied and historically occupied reaches for research, monitoring, and to provide population redundancy (USFWS, 2018).

Conservation Measures and Best Management Practices:

- Recovery Objectives and Actions: Objective: 1.0 Protect, restore, and enhance existing and new THS and host fish populations, connectivity, and habitats throughout its historical range (increases resiliency and redundancy). Action. 1.1. Further delineate the current status and distribution of the THS throughout its historical range (Priority 1) Action. 1.2. Institute a monitoring program to assess performance of THS populations within GMUs supporting extant (Black, Rio Grande-Lower Canyons and Laredo, Devils rivers, and Rio San Diego Units) and reestablished (Delaware, Lower Pecos, and/or Las Moras Units) stream populations (Priority 2). Action. 1.3. Identify current and potential threats within all GMUs (Priority 1) Action, 1.4. Carry out regulatory and voluntary projects using existing programs to protect the species and habitat, restore degraded habitat, improve watersheds to reduce erosion and sedimentation, and improve connectivity within and between all GMUs (Priority 1). Action. 1.5. Research population and community ecology for THS and its host fishes in all GMUs (Priority 2) Action. 1.6. Research population genomics of THS among and within extant GMUs (Priority 2). Action. 1.7. Characterize resiliency of THS within each GMU (Priority 2) Objective. 2.0 Ensure protection of flow regimes required for long-term persistence of THS, its habitat, and host fishes throughout the THS historical range (increases resiliency). Action. 2.1. Determine flow requirements for population performance of THS and its host fishes in GMUs supporting extant stream populations (Priority 1). Action. 2.2. Investigate regional hydrology (source of recharge zones of the aquifers that support stream flows) for ground water management and conservation for all GMUs (Priority 1). Action 2.3. Develop and implement an emergency response strategy for mussel kills and major drought /low water conditions for extant stream populations (Priority 1). Action. 2.4. Purchase, lease, or otherwise utilize water rights to provide the necessary flow regimes identified in Recovery Action 2.1 (Priority 2). Objective. 3.0 Ensure adequate water quality in all GMUs with an emphasis on GMUs supporting extant stream populations (Black, Rio Grande-Lower Canyons and Laredo, Devils rivers and Rio San Diego GMUs). Action. 3.1. Determine sensitivities and exposures to various contaminants suspected to have adverse effects to all life stages of THS and its host fishes (Priority 1). Action. 3.2. Determine sensitivities to low dissolved oxygen, salinity, extremes in temperature, pH, and other water quality parameters to all life stages of THS and its host fishes (Priority 1). Action. 3.3. Develop and implement management plans to retain and promote adequate water quality for all GMUs (Priority 1). Objective. 4.0. Identify suitable sites for THS reintroduction and implement habitat restoration and THS reintroduction within GMUs identified in historical range (e.g., Lower Pecos, Delaware, and Las Moras Units). Action. 4.1. Identify suitable streams for future reintroduction of THS within the historical range (e.g., Lower Pecos, Delaware, and Las Moras Units) and implement reintroduction (Priority 2). Action. 4.2. Identify and Implement habitat restoration at sites identified in Action 4.1. (Priority 2). Objective. 5.0. Initiate educational and public outreach actions to heighten awareness of THS as an endangered species, and solicit help from stakeholders with recovery actions throughout the species' historical range. Action. 5.1. Identify and engage stakeholders throughout the historical range (Priority 2). Objective. 6.0. Conduct periodic reviews and track recovery progress throughout THS historical range. Action. 6.1. Evaluate status of THS in terms of recovery criteria (Priority 3). Action. 6.2. Review new information every five years and update THS Recovery plan as needed (Priority 3). (USFWS, 2022)

- RECOMMENDATIONS FOR FUTURE ACTIONS Future actions for Texas Hornshell should primarily focus on highest priority needs of the species and its habitat in order to reduce threats and aid in species recovery. Future actions will require continued partnership with research universities and organizations implementing conservation measures in areas with Texas Hornshell present, and new partnerships with local water management organizations. The following activities (from the Texas Hornshell Recovery Implementation Strategy available on the Species ECOS webpage) are not listed in any order and may change as new information becomes available for the species: • Continue conducting regular surveys of extant stream populations of Texas Hornshell (recovery activity 1.1.1). Surveys were conducted on all populations in 2018; however, several populations are small and known to be experiencing drought. It is important to continue regular surveys to determine species abundance of each population and monitor known threats to each. • Determine threats within each population (recovery activity 1.3.1). There are known threats for each population but based on various projects, water management resources, and climate change in each area, the impact and strength of threat can change annually. It is important to monitor threats to understand what is occurring on the landscape and the impact they have on each population. • Develop and maintain a GIS database to map threats, habitat conditions, land use, and existing conservation efforts with respect to the location and status of Texas Hornshell populations within each identified geological management unit (recovery action 1.3.2). Having this database would help the Service and its partners prioritize threats and populations and keep record of ongoing projects near known populations. Habitat modeling has been conducted by university partners and there is a funded project that will conduct a field survey (2024) to determine the accuracy of the habitat model that has been developed. • Investigate the biology, habitat use, and ecology of Texas Hornshell early life stages within all geological management units (recovery activity 1.5.1). The complex life cycle of Texas Hornshell mussels is relatively understudied, although knowledge of juvenile feeding ecology, habitat use, glochidia development time, and thermal optima are important for species recovery. • Develop and optimize captive propagation techniques in support of scientific research in case of catastrophic extirpation (recovery action 1.5.5). Given the threats wild populations face from environmental stochasticity, in the event of a catastrophic event captive propagation would aid in the recovery of severely impacted populations. • Identify negative impacts of groundwater use on surface flows (recovery action 2.2.2). This would focus on areas with excessive groundwater pumping and would provide more information on ongoing threats to Texas Hornshell populations. • Work with water rights owners to identify opportunities for water right leases, purchases, or donations (recovery action 2.4.2). Given the need for continual water flow, it is important to analyze water rights usage and identify potential water right owners to form partnerships to aid in recovery of Texas Hornshell. • Determine tolerance to various contaminants and combinations of contaminants suspected to have adverse effects on Texas Hornshell and host fishes (e.g., hydrocarbons, ammonia, chlorine, and heavy metals; mixtures such as production water, herbicides, and pesticides (recovery activity 3.1.1). Freshwater mussels are threatened with decreased water quality, through increased chemical exposure. It is important to understand the lethal and sublethal impacts of various chemicals on all life stages. • Based on findings from other recovery actions identify sites for habitat restoration (recovery action 4.1.4). In addition to population monitoring long term recovery will require enhanced habitat to maintain populations of Texas Hornshell (USFWS, 2023).

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2013 U.S. Fish and Wildlife Service. 2018. Recovery Outline for Texas hornshell. U.S. Fish and Wildlife Service. Texas Coastal Ecological Services Field Office. Houston, Texas. 14 pp.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2013

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2013. USFWS. 2023. Texas Hornshell (Popenaias popeii) 5-Year Status Review: Summary and Evaluation. U.S. Fish and Wildlife Service Texas Coastal Ecological Services Field Office. 16 pages.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 03/01/2019

U.S. Fish and Wildlife Service. 2018. Recovery Outline for Texas hornshell. U.S. Fish and Wildlife Service. Texas Coastal Ecological Services Field Office. Houston, Texas. 14 pp.

USFWS. 2022. Final recovery plan for Texas hornshell, Popenaias popeii (Lea, 1857). U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico. 31 pages.

USFWS. 2022. Recovery implementation strategy Texas hornshell (Popenaias popeii). U.S. Fish and Wildlife Service Houston, Texas. 22 pages.

USFWS. 2023. Texas Hornshell (Popenaias popeii) 5-Year Status Review: Summary and Evaluation. U.S. Fish and Wildlife Service Texas Coastal Ecological Services Field Office. 16 pages.

SPECIES ACCOUNT: *Potamilus amphichaenus* (Texas heelsplitter)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

The Texas Heelsplitter is a medium to large-sized freshwater mussel (up to 177 mm shell length) that has a tan to brown or black elliptical shell, with lighter coloration on the beaks. The hinge line is relatively straight. Texas Heelsplitter exhibit slight sexual dimorphism; females have a broadly rounded posterior margin and males are more pointed (Howells 2010b, p. 2). The base of the anterior margin exhibits a long, narrow gape, while a shorter, much wider gape is located along the posterior margin, presumably to accommodate the incurrent and excurrent apertures (Neck and Howells 1995, p. 4). Burlakova et al. (2011, p. 158) considered the species rare throughout its range (USFWS, 2022).

Taxonomy

The Texas Heelsplitter (Figure 2.4) was first described as the species Unio (Lampsilis) amphichaenus by Frierson (1898, p. 109) from the Sabine River near Logansport, Louisiana. Vidrine (1993), Neck and Howells (1995, p. 4), and Howells (1996, p. 95) recognized the following synonyms (Howells 2010b, p. 4): Unio (Lampsilis) amphichaenus of Frierson (1898); Lampsilis (Proptera) amphichaenus (Frierson 1898) of Simpson (1900); Lampsilis (Proptera) amphichaena (Frierson 1898) of Simpson (1914); Proptera amphichaena (Frierson 1898) of Frierson (1927) and Haas (1969); Leptodea amphichaena (Frierson 1898) of Burch (1975); Lastena amphichaena (Frierson 1898) of Hoggarth (1988); Potamilus amphichaenus (Frierson 1898) of Turgeon et al. (1988), Williams et al. (2017a), and others. The recognized scientific name for Texas Heelsplitter is Potamilus amphichaenus, and this report refers to it as such. The following taxonomic treatment follows Williams et al. (2017a, pp. 35, 42). CLASS Bivalvia Linnaeus, 1758 CLASS Bivalvia Linnaeus, 1758 ORDER Unionida Gray, 1854 FAMILY Unionidae Rafinesque, 1820 SUBFAMILY Ambleminae Rafinesque, 1820 TRIBE Lampsilini Ihering, 1901 GENUS Potamilus Rafinesque, 1818 SPECIES Potamilus amphichaenus (Frierson, 1898) (USFWS, 2022).

Historical Range

The Texas Heelsplitter is endemic to the Neches, Sabine, and Trinity River drainages of east Texas (Howells et al. 1997, pg. 22). The type locality specimen was described by Frierson in 1898 from the Sabine River on the Texas – Louisiana border near Logansport, Louisiana (Frierson 1898, pg. 109). Within the Neches River drainage, the Texas Heelsplitter has been recorded at multiple locations throughout the system below Lake Palestine, including areas downstream of B.A. Steinhagen Reservoir (Vidrine 1993, pg.159; Howells et al. 1996, pg. 96; Howells et al. 1997, pg. 8, 22; Howells 2006, pp. 25-33; Ford et al. 2014, pg. 10; Ford et al. 2016, p. 22; Randklev 2018, entire; Bio-West 2019, unpublished data) (see Figure 3.2). Within the Sabine River drainage, the species has been recorded at several locations throughout the system from Lake Tawakoni to below Toledo Bend Reservoir (Vidrine 1993, pg. 159; Howells et al. 1996, pg. 96; Howells 2006 pp. 17- 21, 83; Ford et al.2010, pg. 6; Hollis 2013, pg. 68; Ford et al. 2016, pg. 22; Randklev 2018, entire). Within the Trinity River drainage, the species has been recorded at several locations throughout the system, including reservoirs, from Lake Lewisville and Lake Grapevine to Lake Livingston (Howells 2006, pg. 42, 48; Bosman et al. 2015, pg. 15; Randklev

2018, entire). We assume the historical distribution of the species would have included the entirety of the river basins described above where connectivity was not an issue and conditions were suitable (see stream segments highlighted black on Figure 3.2)(Note: our estimates of historical range include the mainstem and major tributaries within basins, but do not include an often vast network of minor tributaries even though these areas may have been occupied by mussels in the past) (USFWS, 2022).

Current Range

The Texas Heelsplitter is endemic to the Neches, Sabine, and Trinity River drainages of east Texas (Howells et al. 1997, pg. 22). The type locality specimen was described by Frierson in 1898 from the Sabine River on the Texas – Louisiana border near Logansport, Louisiana (Frierson 1898, pg. 109). Within the Neches River drainage, the Texas Heelsplitter has been recorded at multiple locations throughout the system below Lake Palestine, including areas downstream of B.A. Steinhagen Reservoir (Vidrine 1993, pg.159; Howells et al. 1996, pg. 96; Howells et al. 1997, pg. 8, 22; Howells 2006, pp. 25-33; Ford et al. 2014, pg. 10; Ford et al. 2016, p. 22; Randklev 2018, entire; Bio-West 2019, unpublished data) (see Figure 3.2). Within the Sabine River drainage, the species has been recorded at several locations throughout the system from Lake Tawakoni to below Toledo Bend Reservoir (Vidrine 1993, pg. 159; Howells et al. 1996, pg. 96; Howells 2006 pp. 17- 21, 83; Ford et al.2010, pg. 6; Hollis 2013, pg. 68; Ford et al. 2016, pg. 22; Randklev 2018, entire). Within the Trinity River drainage, the species has been recorded at several locations throughout the system, including reservoirs, from Lake Lewisville and Lake Grapevine to Lake Livingston (Howells 2006, pg. 42, 48; Bosman et al. 2015, pg. 15; Randklev 2018, entire). We assume the historical distribution of the species would have included the entirety of the river basins described above where connectivity was not an issue and conditions were suitable (see stream segments highlighted black on Figure 3.2)(Note: our estimates of historical range include the mainstem and major tributaries within basins, but do not include an often vast network of minor tributaries even though these areas may have been occupied by mussels in the past) (USFWS, 2022).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Lifespan

Adult: A congener (Potamilus purpuatus (common name Bluefer)) from the southeast United States was reported by Haag and Rypel (2011) to reach a maximum age of 9–26 years (Table 1, p. 229) and members of tribe Lampsilini ranged from 4–50 years (p. 234) with a higher growth rate compared to other tribes (p. 239). Texas Heelsplitter has been reported mature at approximately 60 mm and juvenile presence has been confirmed in the Sabine River (USFWS, 2022).

Reproduction Narrative

Adult: Although information specific to Texas heelsplitter reproduction is unavailable, other species from the tribe Lampsilini release glochidia in packets, called conglutinates, and are known to use mantle lures to attract sight feeding fishes that attack and rupture the marsupium, thereby becoming infested by glochidia (Barnhart et al. 2008, p. 377, 380). Most species of Lampsilini are long-term brooders (bradytictic) (p. 384). Howells (2010b) observed eggs and glochidia from two females during January from the Neches River; however, 13 others collected in January, July, and August were not gravid (p. 3). A single female, 90 mm in shell length, was estimated to have 6,665 eggs and 871,665 glochidia while another female with a 104 mm in shell length had 599,375 eggs and 646,250 glochidia (Howells 2010b, p. 3). Freshwater Drum (Aplodinotus grunniens) were confirmed as host fish for Texas Heelsplitter (Bosman et al. 2015, p. 15). Freshwater mussel recruitment does not occur every year (USFWS, 2022).

Habitat Type

Adult: Rivers and streams (USFWS, 2022)

Habitat Narrative

Adult: Texas Heelsplitter occur in streams and rivers of the Trinity, Neches, and Sabine River drainages on substrates consisting of “firm mud, sand, or finer gravels bottoms, in still to moderate flows” and sometimes associated with fallen timber (Howells 2014, p. 69; Howells 2010b, p. 3, and Table 2.3). Vaughan (2017, p.15) collected specimens in substrates with high organic matter content. Dickson (2018, p. 23) reported Texas Heelsplitter were found in areas of large channel widths, with at least one low bank, in sandy substrates, at depths of 10 cm and deeper within the substrate, and in areas prone to bankfall. Texas Heelsplitter can tolerate man-made impoundments and have been found in several east Texas reservoirs (USFWS, 2022).

Dispersal/Migration

Population Information and Trends

Population Trends:

Declining (USFWS, 2022)

Resiliency:

Currently, Texas Heelsplitter are known to exist as five populations occurring in three adjacent river basins: the Neches, Sabine, and Trinity (USFWS, 2022).

Representation:

We consider the Texas Heelsplitter to have representation in the form of genetic, geographic, and ecological diversity in the three currently occupied river basins. Because there are no freshwater connections between the three basins, we treated each river basin as separate areas of representation (USFWS, 2022).

Redundancy:

Within the identified Texas Heelsplitter representation areas (Neches, Sabine, and Trinity River basins), only the Neches and Trinity River basins have at least one known current viable population (the Sabine River/Toledo Bend population in the Sabine River basin and Grapevine Lake in the Trinity River basin are considered functionally extirpated/extirpated). The Neches River basin has two currently viable populations (Neches River and Lower Neches River populations); however, these populations are hydrologically isolated, and therefore provide only minimal redundancy (USFWS, 2022).

Number of Populations:

5 (USFWS, 2022)

Population Narrative:

Based on our analysis, the total combined stream length currently occupied by the five known Texas Heelsplitter populations described in Chapter 3 equals 764 river miles, including four reservoirs, which is approximately 24.3% of more than 3,146 river miles that the species may have occupied historically. This approximate range reduction assumes the species continuously occupied its entire historical range, which is unlikely given the species' specialized habitat preferences. However, our estimates of historical range are based solely on river miles within the mainstem and major tributaries, and therefore take a conservative approach since they do not include a significant number of minor tributaries for which we lack records but that may have been occupied at one time. Due to a lack of research into Texas Heelsplitter habitat needs in lacustrine environments and uncertainty whether those populations function as viable populations, no attempt was made to quantify occupied habitat in reservoirs (USFWS< 2022).

Threats and Stressors

Stressor: Direct mortality (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Direct mortality (USFWS, 2022)

Stressor: Altered hydrology (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Altered hydrology (USFWS, 2022)

Stressor: Invasive species (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Invasive species (USFWS, 2022)

Stressor: Climate change (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Climate change (USFWS, 2022)

Stressor: Changes in water quality (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Water quality can be degraded through contamination or alteration of water chemistry. Environmental contaminants include a broad array of natural, synthetic, and chemical

substances introduced to the environment that can be hazardous to living organisms. Chemical contaminants are ubiquitous throughout the environment and are a major contributor to the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Contaminants that enter the environment are generally categorized by their origin as either coming from point sources such as hazardous spills, industrial wastewater, and municipal effluents, or non-point sources such as urban stormwater and agricultural runoff. These discharges can introduce a variety of pollutants to air, water and soil, including organic compounds, trace metals, pesticides, plastics, petroleum hydrocarbons, flame retardants, and a wide variety of emerging contaminants (e.g., pharmaceuticals and personal care products) that comprise some 85,000 chemicals in commerce today and are routinely released into the aquatic environment (EPA 2018, p. 1). The extent to which environmental contaminants adversely affect aquatic biota can vary depending on many site-specific variables (e.g., the concentration of the pollutant, the volume discharged, and the timing of the release), but species diversity and abundance consistently ranks lower in waters that are known to be polluted or otherwise impaired by contaminants. For example, freshwater mussels are not generally found for many miles downstream of municipal wastewater treatment plants (WWTP)(Gillis et al. 2017, p. 460; Goudreau et al. 1993, p. 211; Horne and McIntosh 1979, p. 119). Transplanted common freshwater mussels (Amblema plicata and Corbicula fluminea) showed reduced growth and survival below a WWTP outfall relative to sites located upstream of the WWTP in Wilbager Creek (a tributary to the Colorado River in Travis County, Texas); water chemistry was altered by the wastewater flows at downstream sites, with elevated constituents in the water column that included copper, potassium, magnesium, and zinc (USFWS, 2022).

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2022. Species status assessment report for two freshwater mussels: Louisiana Pigtoe (Pleurobema riddellii) and Texas Heelsplitter (Potamilus amphichaenus). Version 1.2. February 2022. Arlington, Texas.

SPECIES ACCOUNT: *Potamilus capax* (Fat pocketbook)

Species Taxonomic and Listing Information

Listing Status: Endangered; 06/14/1976; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A rounded, greatly inflated shell, thin to moderately thick, s-shaped hinge line, tan or light brown, rayless, and shiny. Shell round to somewhat oblong, greatly inflated, and thin (young) to moderately thick (adults). Anterior and posterior ends rounded. Umbos greatly inflated, elevated, and turned inward. Beak sculpture consists of a few faint ridges, visible only in young shells. Small posterior wing present in young mussels. Surface usually smooth and very shiny. Periostracum rayless, yellow, yellowish tan or olive, becoming dark brown in older individuals. The length is up to 5 inches. Pseudocardinal teeth thin, compressed, and elevated; two in each valve. Lateral teeth thin and greatly curved; two in the left valve, one in the right. Hinge line S-shaped. Beak cavity very deep. Nacre white, sometimes tinged with pink or salmon in the beak cavity. (NatureServe, 2015)

Taxonomy

This is a member of the widely distributed genus Potamilus. This species was formerly placed in the genus Proptera which was widely used in the 1950s and 1960s. A recent ruling published in the Bulletin of Zoological Nomenclature (ICZN, 1992) recommended retention of the older name Potamilus. In an analysis of systematic relationships of species in the genus Potamilus using DNA sequence data, Roe and Lydeard (1998) concluded that Potamilus is paraphyletic with Leptodea fragilis and Lampsilis ornata nested between Potamilus capax and the remaining Potamilus species (all of which appeared to be monophyletic). Roe and Lydeard (1998) placed Potamilus capax outside the remaining members of Potamilus in their phylogenetic tree indicating possible affinities with other taxa but did not go so far as to formally recommend a genus in which to place P. capax, although Simpson (1914) placed it in Lampsilis. (NatureServe, 2015)

Historical Range

Based largely on museum records, this species was formerly present in the upper Mississippi River (above St. Louis, Missouri); the Wabash River, Indiana; and the St. Francis River, Arkansas (Harris et al., 1997), including: Minnesota, Wisconsin, Iowa, Illinois, Indiana, Missouri, Kentucky, and Arkansas (USFWS, 1989). The St. Francis River is the center of historical distribution and maintains the best habitat and healthiest populations today. There is contradictory information as to whether this species was historically uncommon (Miller and Payne, 2005) or once much more common and widespread than it is today with live Potamilus capax records from the Mississippi River from Adams Co., Mississippi, to Phillips Co., Arkansas (Paul Hartfield, USFWS, pers. comm., 2007). (NatureServe, 2015)

Current Range

Since 1970, the species has been found extant in portions of the St. Francis River (Jenkinson and Ahlstedt, 1995), with scattered records from the Wabash and Ohio Rivers in Indiana and Kentucky (Sickel, 1987; Cummings et al. 1990; Cummings and Mayer, 1993) and in southeastern Missouri (anonymous, 1996). In Mississippi River north and Mississippi River south drainages in Mississippi, including a discovered (2003) population in Jefferson County (Jones et al., 2005). Note records from the Green River, Kentucky are unsubstantiated as are Branson's (1963)

Oklahoma records, as well as records from Kansas (Murray and Leonard, 1962) are incorrectly figured Potamilus purpuratus (USFWS, 1989). (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: No information available for this species. Based on P. dolabelloides: Larvae (glochidia) of freshwater mussels generally are parasitic on fish and display varying degrees of host specificity. General literature claims that mussels are filter-feeders that remove phytoplankton from the water column. These assumptions are based on casual observations on mussels in situ and a few examinations of rectal contents. Baker (1928) speculated that detritus was the primary energy source. This has been substantiated by James (1987) and correlates well with observed microhabitat utilization (NatureServe, 2015).

Reproduction Narrative

Adult: Preliminary results from an unpublished study by Barnhart (1996), Barnhart and Roberts (1996), Barnhart and Andrews (1997), Barnhart and Riusech (1997), and Watters (1994) found successful glochidial metamorphosis on the freshwater drum, Aplodinotus grunniens (NatureServe, 2015). Potamilus canax is probably a long-term breeder (bradytictic), and is reported gravid in June, July, August and October (Surber 1912, Ortmann 1914) (USFWS, 1989).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate to broad (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: High (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Dependency on Other Individuals or Species for Habitat

Adult: Sand, mud, and fine gravel substrates (NatureServe, 2015)

Habitat Narrative

Adult: This species is found in sand, mud, and fine gravel substrates and flowing water (Dennis, 1985). It is also found in large rivers in slow-flowing water (often near the bank) in mud or sand (Cummings et al., 1990). Recently, it has been found to be tolerant of depositional areas that are usually unfavorable to other mussel species and is in fact, not a lotic species as indicated in the Recovery Plan (USFWS, 1989) that is negatively affected by high sedimentation rates. In fact, man-made ditches and existing bayous, sloughs, and streams in the St. Francis watershed provide suitable habitat (Miller and Payne, 2005). This species is highly to moderately vulnerable, with a moderate to broad environmental specificity. Recently, this species was found to be tolerant of depositional areas that are usually unfavorable to other mussel species and is in fact, not a lotic species as indicated in the Recovery Plan (USFWS, 1989) that is negatively affected by high sedimentation rates. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 70-90% (NatureServe, 2015)

Species Trends:

Improving (USFWS, 2012)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

10,000 - 100,000 individuals (NatureServe, 2015)

Adaptability:

Moderate (inferred from NatureServe, 2015)

Population Narrative:

Historically, the fat pocketbook has undergone a marked decline in its overall range and is now limited to two regions (lower Wabash and Ohio rivers and the St. Francis River drainage and portions of the bootheel in Missouri); and is extirpated from Minnesota (formerly Mississippi River below St. Anthony Falls) (Sietman, 2003) plus a new population in Mississippi (Jones et al., 2005). Miller and Payne (2005) conclude that no evidence exists that this species was ever abundant outside Arkansas although it was collected along the Ohio and Wabash Rivers (Miller and Payne, 2005). However, live Potamilus capax records exist from the Mississippi River from Adams Co., Mississippi, to Phillips Co., Arkansas, indicating a much more wider historic distribution than was previously believed (Paul Hartfield, USFWS, pers. comm., 2007). The species formerly occurred in New York at two sites in the Niagara River and Wilsons Creek = Twelvemile Creek) in Niagara Co. in the northwest part of the state from over a century ago (Strayer and Jirka, 1997). It probably disappeared from the Upper Illinois River about 1900 and from the Lower Illinois River in 1920 (USFWS, 1989). It formerly occurred in the lower Sangamon River in Illinois but is likely extirpated there (Schanzle and Cummings, 1991). This species has experienced a long-term decline of 70-90%. The range extent of this species is 400 - 2,000 square miles, with an estimated population size of 10,000 - 100,000 individuals. There are 6 - 20 occurrences, with 1 - 12 occurrences having good viability/integrity (NatureServe, 2015). The species status is improving, based on the 2011 Recovery Data Call (USFWS, 2012).

Threats and Stressors

Stressor: Habitat modification (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Dredging and impoundments are the primary cause for decline. Mussels are particularly susceptible to dredging and must be relocated in order to survive. The Upper Mississippi River has been impounded for navigation and is dredged routinely and this species, once widespread in the river, has disappeared in recent years. The largest population occurs in the St. Francis Floodway. This watershed has been substantially altered by local interests and the U.S. Army Corp to subsidize agricultural interests. Most of the stream channels have been dredged or straightened under the guise of flood control. Much of the substrate of the White River, Arkansas, consists of shifting sandbars with stable substrate only along the bank where some undredged mud ledges remain (USFWS, 1989). Siltation has also been associated with reduction in populations of this species. Recently, however, the species has been found to be tolerant of depositional areas that are usually unfavorable to other mussel species and is in fact, not a lotic species as indicated in the Recovery Plan (USFWS, 1989) that is negatively affected by high sedimentation rates. In fact, man-made ditches and existing bayous, sloughs, and streams in the St. Francis watershed provide suitable habitat (Miller and Payne, 2005) (NatureServe, 2015).

Stressor: Pollution (NatureServe, 2015)

Exposure:
Response:
Consequence:
Narrative: Pollution may also affect this species but the effects have not been well studied (USFWS, 1989) (NatureServe, 2015).

Stressor: Zebra mussel (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Since the fat pocketbook was listed, the Ohio, Mississippi, and White (Arkansas) rivers have been occupied by the invasive zebra mussel (Dreissena polymorpha). Effects of zebra mussels on native unionids may include competition for food and habitat resources (Hunter et al. 1996, Scholesser et al. 1996) (USFWS, 2012).

Stressor: Stochastic events (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (for example, Golladay et al. 2004; McLaughlin et al. 2002; Lubchencho and Carl 2012). Information in our files documents mollusk declines within small perennial streams that have lost flow as a direct result of drought (for example, Golladay et al. 2004; Haag and Warren 2008). Habitats occupied by the fat pocketbook include small streams and ditches to large rivers. Low gradient ditches and streams (e.g., upper St. Francis drainage) and large rivers (e.g., Mississippi, Ohio, St. Francis, Ouachita rivers) where fat pocketbook is known to occur are less susceptible to total loss of flow by drought (USFWS, 2012).

Recovery

Reclassification Criteria:
1. The existing population in the St. Francis drainage is protected from habitat modification (USFWS, 2012).

2. At least two additional viable populations are located (or established) and protected in two other river systems within the historical range of the species (USFWS, 2012).

Delisting Criteria:
The fat pocketbook mussel will be considered for delisting when: 1) All three drainage populations (St. Frances, Ohio and Mississippi River) exhibit a stable or increasing trend, evidenced by natural recruitment, and multiple age classes (Factors A, D) 2) Fat pocketbook mussels are documented from a minimum of 12 sites along 200 km (125 mi) reaches within each of the St. Francis, Ohio, and Mississippi drainages (Factors A,E). 3) Active USACE management programs are in place, and assured to continue into the foreseeable future, within each of the three drainages leading to maintenance or improvement of fat pocketbook mussel habitats and population expansion (Factors A, D). (USFWS, 2019)

Recovery Actions:

- Preserve existing populations in St. Francis River system (USFWS, 1989).
- Determine if viable populations exist outside the St. Francis River (USFWS, 1989).
- Conduct life history studies of this species (USFWS, 1989).
- Establish two populations outside the St. Francis River, if necessary (USFWS, 1989).
- Develop an educational program (USFWS, 1989).
- Update the Recovery Plan to include new information and updated measurable recovery criteria (USFWS, 2012).
- Develop and implement monitoring plans for populations and activities associated with the St. Francis, Ohio, and Mississippi river drainage populations (USFWS, 2012).
- Work with partners to develop conservation strategies and plans for each drainage population (USFWS, 2012).
- Conduct additional research on fat pocketbook, including identifying mussel/host fish interactions (USFWS, 2012).

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

U.S. Fish and Wildlife Service, 1989. A Recovery Plan for the Fat Pocketbook Pearly Mussel Potamilus canax (Green 1832). U.S. Fish and Wildlife Service. Atlanta, Georgia. 22 pp.

USFWS 2012. Fat Pocketbook (Potamilus capax) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Mississippi Ecological Services Field Office Jackson, Mississippi.

USFWS. 2012. Fat Pocketbook (Potamilus capax) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Mississippi Ecological Services Field Office Jackson, Mississippi.

USFWS 2012. Fat Pocketbook (Potamilus capax) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Mississippi Ecological Services Field Office Jackson, Mississippi

USFWS 2012. Fat Pocketbook (Potamilus capax) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Mississippi Ecological Services Field Office, Jackson, Mississippi.

USFWS. 2019. Amendment 1. Recovery Plan for Fat Pocketbook Mussel (Potamilus capax). 5 pp.

SPECIES ACCOUNT: *Potamilus inflatus* (Alabama (=inflated) heelsplitter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 09/28/1990; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A freshwater mussel or bivalve mollusk which reaches a maximum adult shell size of about 140 millimeters (mm) or 5 ½ inches (in) in length. The shell is brown to black and may have green rays in young individuals. (NatureServe, 2015)

Taxonomy

According to Roe and Lydeard (1998) this taxa consists of two geographically isolated and genetically distinct species. There has been considerable debate in regard to the generic name. It has been called UNIO, LAMPSILIS, METAPTERA, MARGARITA, MARGARON, and PROPTERA (U. S. Fish and Wildlife Service 1992). POTAMILUS is the name recognized by the American Fisheries Society (Turgeon et al. 1988; 1998).0s and 1960s. A recent ruling published in the Bulletin of Zoological Nomenclature (ICZN, 1992) recommended retention of the older name Potamilus. In an analysis of systematic relationships of species in the genus Potamilus using DNA sequence data, Roe and Lydeard (1998) concluded that this taxa consists of two geographically isolated and genetically distinct species, one in the Amit drainage and the other in the Black Warrior drainage. (NatureServe, 2015)

Historical Range

This species is known historically from the Amite and Tangipahoa rivers, Louisiana; the Pearl River, Mississippi; and the Tombigbee, Black Warrior, Alabama, and Coosa Rivers, Alabama. Historically, it occurred in the Pearl and Tombigbee River drainages in Mississippi and close by in lower Amite River in Louisiana (Jones et al., 2005). (NatureServe, 2015)

Current Range

The current distribution is limited to the Amite River, Louisiana and the Tombigbee and Black Warrior Rivers, Alabama (USFWS, 1992). Mirarchi et al. (2004) list distribution as the Alabama, Black Warrior, Coosa and Tombigbee Rivers of the Mobile basin. Roe and Lydeard (1998) content that the Amite and Black Warrior drainage populations represent two, geographically isolated, distinct species. (NatureServe, 2015). The species currently occupies a larger extent of habitat in the East Fork Tombigbee, in Mississippi, and the Tombigbee and Black Warrior rivers, in Alabama, than was known at the time of listing. Some individuals (<10) have also been reported in the Alabama River, in Alabama (Hartfield and Garner 1998 pers. comm.; USACE pers. comm.). In May 2000, one fresh dead shell of an inflated heelsplitter was located near river mile 112, below the Pursley Creek confluence (USACE pers. comm. 2024). Follow-up sampling in the Alabama River should occur to better understand the range in this river system. In the Amite River, the inflated heelsplitter occurs from approximately, French Settlement upstream to Denham Springs, Livingston Parish, Louisiana. The Louisiana Department of Wildlife and Fisheries (LDWD 2024 pers. comm.) conducted surveys in the Amite River the summer of 2023, and confirmed their continued presence. The species' current range in the Tombigbee River, in Mississippi, is fragmented by the TennesseeTombigbee Waterway, with one subpopulation documented in the lower end of the Buttahatchee River and the other found in the East Fork Tombigbee River. The East Fork of the Tombigbee River population extends from the mouth of the East Fork Tombigbee upstream to the mouth of Mill Creek. The species was also recently (2022) detected in the lower cutoff section of Bull Mountain Creek, where a single live individual was reported (USFWS 2023 pers. comm.). Recent surveys conducted by the Service's, Mississippi Ecological Services Field Office, reported a range of sizes of inflated heelsplitter in the East Fork Tombigbee (USFWS 2023 pers. comm.), indicating recruitment. The species' range in the Black Warrior, Middle to Lower Tombigbee, and Sipsey rivers remains the same since the previous 5-year-review (Service 2018). This is an expansion of the range since the time of listing. The species is considered stable in this portion of the Mobile Basin (USFWS, 2024).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Mussels are dependent upon the water currents to bring food particles within the range of their siphons (USFWS, 1992).

Reproduction Narrative

Adult: Species in the genus Potamilus are long-term breeders. Investigations by Roe et al. (1997) found the freshwater drum (Aplodinotus grunniens) to be a suitable fish host for the glochidia of this species (NatureServe, 2015). Gravid females have been collected from the Amite River, Louisiana, during October (Hartfield 1988) (USFWS, 1992).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species is found in sand, mud, silt, and sandy-gravel substrates in slow to moderate currents and is usually collected on the protected side of bars in water as deep as 20 feet (Stern, 1990). It has not been found in large gravel. The preferred habitat is soft, stable substrates in slow to moderate currents (USFWS, 2000). This species is highly to moderately vulnerable. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 70-90% (NatureServe, 2015)

Species Trends:

Stable (USFWS, 2018)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

1000 - 10,000 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). This species has experience a long-term decline of 70-90%. The range extent is 400 - 2,000 square miles, with an estimated population size of 1,000 - 10,000 individuals. There are 6 - 20 occurrences, with 1 - 3 occurrences having good viability/integrity (NatureServe, 2015). When listed, the inflated heelsplitter was known to occur at a few locations in the Tombigbee and Black Warrior rivers, Alabama, and in the Amite River, Louisiana. It was believed extirpated from the Tangipahoa, Pearl, Alabama, and Coosa rivers . The species continued to persist in the Amite River at relatively low levels from the vicinity of Denham Springs downstream to Port Vincent, Livingston/East Baton Rouge Parish, LA (Brown and Curole 1997). A more recent survey, however, indicates that the species disappeared from the upper 6 km of this reach between 1994 and 2007 and catch per unit effort for inflated heelsplitter declined in the downstream reaches (Brown and Daniel 2014). Inflated heelsplitter range in the Mobile River Basin has expanded since listing. In the Black Warrior River, the range of the species has been extended from its confluence with the Tombigbee River, upstream to Tuscaloosa, Tuscaloosa County, Alabama (Miller 1994, Hartfield and Gamer 1995, McGregor in litt. 2009). In the Tombigbee River, the range has been extended from its confluence with the Alabama River, Mobile County, AL, upstream into the East Fork Tombigbee River, Itawamba County, MS (McGregor and Gamer 2001, 2002, 2003; Jones in litt. 2009, Gangloff and Hamstead 2012). The inflated heelsplitter has also been collected from the lower Sipsey River, Greene County, AL (McGregor and Haag 2004). A single animal has been collected from the lower Alabama River, Baldwin/Clark County, AL (Hartfield and Gamer 1998). A very small population may persist in the lower Pearl River, St. Tammany Parrish, LA (George et al. 1996, Brown i11 litt. 2007). However, recent surveys conducted on the lower Pearl River have failed to locate inflated heelsplitter (Miller et al. 2016, Sikes in litt. 2016) (USFWS, 2018). The historical range of this species spans Louisiana, Mississippi, and Alabama with known populations in the Amite and Tangipahoa rivers in Louisiana, Pearl River in Mississippi, and the Tombigbee, Coosa, and Black Warrior rivers in Alabama (Hartfield 1988). However, the species distribution was restricted to the Amite River in Louisiana and the Tombigbee and Black Warrior Rivers in Alabama at the time of listing in 1990 (USFWS 1993). Pearl River System Two live individuals and shells from three dead individuals are the only records of the species reported from the Pearl River (Frierson 1911; George and Reine 1996; Smith and Johnson 2020). Since the last review additional surveys have been conducted to determine inflated heelsplitter presence in the Pearl River system. The Service and Louisiana Department of Wildlife and Fisheries (LDWF) conducted mussel surveys in the Bogue Chitto National Wildlife Refuge (NWR) and in surrounding waterways including Bogue Chitto River, Holmes Bayou, Wilson Slough, the West Pearl River and the Pearl River proper, along with adjacent backwater sloughs and remnant river channels (USFWS 2018; LDWF 2024 pers. comm.). Twenty-three sample sites within the NWR were surveyed, plus an additional 27 sites on adjacent water ways and tributaries; inflated heelsplitter was one of the at-risk and federally listed mussels targeted in this survey. No inflated heelsplitter individuals or shells were found during this survey. The report stated “Specimens of Potamilus inflatus, listed as threatened, were not found in the sampled areas of this project, and have not been found in recent surveys in the Pearl River watershed. Their population seems to be greatly diminished, or possibly extirpated.” The Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) conducted targeted surveys for the inflated heelsplitter in the Pearl River in 2020 and the Pearl, Strong, and Yokanookany rivers in 2022 (MDWFP 2020 and 2023). In 2020, surveys were focused in the Pearl River below Ross Barnett Reservoir. No inflated heelsplitter individuals or shells were found at the three sites surveyed. In 2022, a more intensive survey was conducted with a total of 118 sites in the mainstem Pearl, Strong, and Yokanookany rivers. Again, no inflated heelsplitter individuals or shells were found. Areas of suitable inflated heelsplitter habitat were documented during both of the survey efforts. The inflated heelpslitter's fish host, freshwater drum (Aplodinotus grunniens), is also present in the Pearl River system. MDWFP has stated "…after our extensive efforts, efforts by Darden et al. (2002), and efforts overtime by MDWFP to re-discover Inflated Heelsplitter and Black Sandshell within Mississippi reaches of the Pearl River, we believe that both species are extirpated from their historic ranges in the Pearl River drainage in Mississippi." The previous 5- year review also recognized the lack of positive survey data, and Hartfield 1988, considered the species extirpated from the Pearl River basin. Due to the number of unsuccessful attempts to detect the inflated heelsplitter in the Pearl River system, the Service has determined the inflated heelsplitter is extirpated from the Pearl River (USFWS, 2024).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 1993)
Exposure:
Response:
Consequence:
Narrative: Conversion of habitat by impoundment, channel maintenance, and gravel mining has reduced the range of Potamilus inflatus. Habitat degradation has resulted in the restriction of this species to limited stretches of three river systems. In the Amite River, there is a continued and serious threat from gravel mining that is largely unregulated. A proposed reservoir upstream of the range of this species may also have an adverse impact. The populations in the mainstem Tombigbee River are affected to a limited extent by channel maintenance activities. In addition, the population below Coffeeville Lock and Dam is not very abundant. The population in Gainesville Bendway may be adversely affected by the regulation of water flows from Gainesville Dam. This structure is designed to allow the passage of normal river flows with the exception of water needed for lockage. During low flows, there is little, if any, water released over Gainesville Dam spillway for varying periods of time. This could result in very low dissolved oxygen conditions on the river bottom in Gainesville Bendway and adversely impact the inflated heelsplitter (USFWS, 1993).

Stressor: Nonnative species (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Recent studies suggest that invasive Corbicula fluminea (Asian Clam) may be an "important but overlooked factor in widespread native mussel declines" (Haag et al. 2021). Corbicula occurs in all streams and sizes across the continental U.S. It was first reported in the eastern U.S. in the 1930's and first documented in the Escambia River in 1960 (Schneider 1967). It is widespread throughout the range of the inflated heelsplitter. In high densities, corbicula can remove substantial amounts of seston (suspended particles) from the water column, reducing food sources and negatively impacting mussel growth (Ferreira-Rodríguez et al. 2018, Haag et al. 2021). The sudden decline of certain mussel species in other Gulf Coast drainages coincided with the appearance of corbicula (Heard 1975). However, the onset of significant perturbations around the same period makes it difficult to determine if corbicula contributed to the declines or

not (Pursifull et al. 2021) (USFWS, 2024).

Stressor: Barriers to host fish movement and reach isolation (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Activities that affect the distribution and abundance of native fishes directly affect mussel distribution and abundance. Dams in the range of the inflated heeslplitter, particularly in the Mobile Basin, impede fish migration routes on Black Warrior and Tombigbee rivers. This likely has implications for the species which uses freshwater drum as its larval host, though it is understood that freshwater drum can pass through dams. Also dams and impoundments isolate occupied reaches of the inflated heelsplitter, reducing the ability for genetic exchange (USFWS, 2024)

Stressor: Climate change – temperature and precipitation (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Climate change has already had adverse impacts on terrestrial, freshwater, and coastal ecosystems globally, and observed increases in temperature extremes, heavy precipitation, drought, and fire have been attributed to climate change (Intergovernmental Panel on Climate Change [IPCC] 2022). In the coming decades, human-induced climate change will push natural and human systems beyond their ability to adapt (IPCC 2022). Climate models forecast more extreme climate and precipitation events in the southeastern U.S. (Carter et al. 2018, LaFontaine et al. 2019). For thermally sensitive mussel species, climate change-induced increases of 3.6–5.4°F may exceed their ability to adapt (Payton et al. 2016). Changes to annual and seasonal streamflow in northern Gulf Coast rivers due to a warmer and wetter climate are predicted (Neupane et al. 2018). Sea level rise from climate change along the U.S. Southeast and Gulf coasts has been rapidly accelerating, with the main drivers of accelerated climate change being greenhouse gas emission and increased global warming. On average, sea level rise is anticipated to be 14 - 18 inches (0.35 - 0.45 meters) for the Gulf coast over the next thirty years. With this shift in sea level rise, major flooding is expected to occur five times as often in 2050 as it does today, which would be exceeded in some locations because of regional and year-to-year variability (USFWS, 2024).

Stressor: Urbanization and Industrial Development (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: A growing threat to the Amite River population is development and urbanization within the basin. Brown et al. (2010) documented declines in occupied habitat and population size resulting from urbanization. Possible reasons for this negative relationship include increased flows in the Amite River contributing to channel instability, unstable flow regimes not suitable to mussels, and increased level of both non-point and point source pollutions. As discussed in the previous 5-year review, impoundments and maintenance dredging continue to threaten the inflated heelsplitter in the Black Warrior and Tombigbee rivers (USFWS, 2024).

Recovery

Reclassification Criteria:
Not available

Recovery Priority Number: 8C

Delisting Criteria:
1. The species has a total of five viable self-sustaining populations that are fully protected and are so located that a single event is not likely to affect any two of them (USFWS, 1992).

2. At least one of the populations must occur in each of the three rivers that have current populations (USFWS, 1992).

3. Evidence of a stable or increasing self-sustaining population over at least 10 years (USFWS, 1992).

Recovery Actions:
- Protect known populations and their habitat from further impacts (USFWS, 1992).
- Conduct life history research (USFWS, 1992).
- Investigate restoration of historic habitat and reestablish populations (USFWS, 1992).
- Develop and implement a plan to monitor all populations (USFWS, 1992).
- Not available
- RECOMMENDATIONS FOR FUTURE ACTIONS - l) Continue conducting studies to evaluate the taxonomic status through morphological and genetic analyses and comparison of inflated heelsplitter drainage populations across the range. Primarily, to answer population and species-level questions between population(s) in the Mobile Basin, Pearl, and Amite rivers. 2) Determine distribution and viability of the Pearl and Alabama River populations. 3) Continue to work with parishes and cities of Baton Rouge and Denham Springs to address impacts of urbanization. 4) Conduct basic research on all populations. 5) Update the Recovery Plan to reflect new information. 6) Change common name in the Federal Register from Alabama heelsplitter to inflated heelsplitter. 7) Develop and implement monitoring plans for the Amite and Pearl rivers and select reaches in the Mobile River Basin. 8) Delineate populations of inflated heelsplitter throughout its range. For example, determine the population structure and size within the Mobile Basin (USFWS, 2018).

Conservation Measures and Best Management Practices:
- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (Service 1993). During the course of this status review new and/or targeted potential recovery activities were identified and are included below. Recovery Activities a. Develop a Controlled Propagation Plan including a Genetics Management Plan, in alignment with U.S. Fish and Wildlife Service policy and execute propagation and stocking efforts for the inflated heelsplitter. b. Evaluate potential introduction and reintroduction sites in the Pearl, Bouge Chitto, Tangipahoa, Comite, and Tickfaw rivers. Evaluate if augmentation of the Amite River is necessary. c. Delineate populations of inflated heelsplitter through its range and study population structure and size. d. Restore and increase in-stream habitat and stream connectivity through conservation actions, including but not limited to improving fish migration (freshwater drum), bank stabilization, riparian buffer maintenance or augmentation, improving water quality downstream of

impoundments, and adherence to BMPs. e. Work with state and federal agencies and private organizations to promote land and water stewardship awareness (e.g., Soil and Water Conservation Districts, Natural Resource Conservation Service (NRCS), State Forestry Commissions, private industry groups, environmental groups, etc.). Monitoring and Research Activities a. Monitor and improve conditions in Bull Mountain Creek to protect inflated heelsplitter in this system. b. Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, and age-specific survival. c. Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. d. Explore using eDNA as a detection tool to provide up-to-date distributional information. Use assays to confirm presence in historical reaches and detect previously unknown populations. e. Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans (USFWS, 2024).

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016. USFWS. 2024. Inflated heelsplitter (Potamilus inflatus) 5-Year Status Review: Summary and Evaluation. Southeast Region. Alabama Ecological Services Field Office. Daphne, Alabama. 15 pages.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

U.S. Fish and Wildlife Service. 1992. Inflated Heelsplitter, (Potamilus inflatus) Recovery Plan. U.S. Fish and Wildlife Service. Jackson, Mississippi. 15 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. U.S. Fish and Wildlife Service. 2018. Inflated Heelsplitter Mussel (Potamilus injlatus). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama USFWS. 2024. Inflated heelsplitter (Potamilus inflatus) 5-Year Status Review: Summary and Evaluation. Southeast Region. Alabama Ecological Services Field Office. Daphne, Alabama. 15 pages.

U.S. Fish and Wildlife Service. 1993. Inflated Heelsplitter (Potamilus inflatus) Recovery Plan. U.S. Fish and Wildlife Service. Jackson, Mississippi. 15 pp.

USFWS. 2024. Inflated heelsplitter (Potamilus inflatus) 5-Year Status Review: Summary and Evaluation. Southeast Region. Alabama Ecological Services Field Office. Daphne, Alabama. 15 pages.

U.S. Fish and Wildlife Service. 2018. Inflated Heelsplitter Mussel (Potamilus injlatus). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama.

SPECIES ACCOUNT: *Ptychobranchus greenii* (Triangular Kidneyshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/17/1993; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A freshwater mussel or bivalve mollusk which attains a maximum adult size of about 100 mm (4.0 in.) in length. The outer shell is straw-yellow in young specimens becoming yellow- brown in older specimens. Occasionally, it may have fine and wavy or wide and broken green rays anterior to the posterior ridge. This species is oval to elliptical in outline. The shell is generally compressed, and may be flattened ventral to the umbos. The posterior ridge is broadly rounded and terminates in a broadly rounded point post-ventrally. The pseudocardinal teeth are heavy, and the laterals are heavy, gently curved and short. The periostracum is straw-yellow in young specimens, but becomes yellow-brown in older ones. It may have fine and wavy, or wide and broken, green rays anterior to the posterior ridge (FWS, 2003). The length is 10 cm. (NatureServe, 2015)

Taxonomy

Spelling of Ptychobranchus greenii is correct as of Turgeon et al. (1998). This species exhibits variable shell morphology and may be confused with some species of Pleurobema . Ecomorphs of the species are best identified by process of elimination (U.S. Fish and Wildlife Service, 1993). Ptychobranchus foremanianus was placed in the synonymy of Ptychobranchus greenii by most previous works. It is recognized in Williams et al. (2008) based on subtle differences in shell coloration, as noted by Ortmann (1923). Preliminary genetic analyses suggest at least two species in the Mobile Basin (K.J. Roe, pers. comm.). The species is now split into Ptychobranchus greenii (Black Warrior and Tombigbee basins) and Ptychobranchus foremanianus (Alabama, Cahaba, Coosa basins). (NatureServe, 2015)

Historical Range

Historically, the range included the Black Warrior Rives and tributaries in Alabama (USFWS, 2004). Additional records include the Black Warrior River and tributaries (Mulberry Fork, Locust Fork, North and Little Warrior Rivers, Brushy Creek, Sipsey Fork). Overall, the species is endemic to the Black Warrior and Tombigbee River drainages of the Mobile Basin in Alabama only (Williams et al., 2008). (NatureServe, 2015)

Current Range

The current range includes the Sipsey Fork and Little Warrior River in the Black Warrior River drainage (USFWS, 1993) with a single record from Coalfire Creek, a tributary of the Tombigbee River well below the Fall Line in Pickens Co. (Williams et al., 2008). Records from the remainder of the Mobile Basin are now recognized as Ptychobranchus foremanianus including Cahaba River specimens (Williams et al., 2008). (NatureServe, 2015)

Critical Habitat Designated

Yes; 7/1/2004.

Legal Description

On July 1, 2004, the U.S. Fish and Wildlife Service (Service) designated river and stream segments (units) in the Mobile River Basin as critical habitat for the triangular kidneyshell, under the Endangered Species Act of 1973, as amended (69 FR 40084 - 40171).

Critical Habitat Designation

Critical habitat is designated for the triangular kidneyshell (Ptychobranchus greenii) in Units 10, 11, 12, 13, 18, 19, 20, 21, 22, 23, 24, 25, and 26; in AL, GA, and TN.

Unit 11. North River and tributary, Tuscaloosa, Fayette Counties, Alabama. Unit 11 encompasses 47 km (29 mi) of river and stream channel in Alabama, including: North River, 42 km (26 mi) extending from Tuscaloosa County Road 38, Tuscaloosa County, upstream to confluence of Ellis Creek, Fayette County, Alabama; Clear Creek, 5 km (3 mi), from its confluence with North River, to Bays Lake Dam, Fayette County, Alabama. Small numbers of the dark pigtoe and orange-nacre mucket continue to survive in the North River and Clear Creek (McGregor and Pierson, 1999; Pierson, 1992a; Vittor and Associates, 1993). This area is in the historic range of the Alabama moccasinshell, triangular kidneyshell, and ovate clubshell.

Unit 13. Cahaba River and tributary, Jefferson, Shelby, Bibb Counties, Alabama. Unit 13 encompasses 124 km (77 mi) of river channel in Alabama, including: Cahaba River, 105 km (65 mi) extending from U.S. Highway 82, Centerville, Bibb County, upstream to Jefferson County Road 143, Jefferson County, Alabama; Little Cahaba River, 19 km (12 mi), from its confluence with the Cahaba River, upstream to the confluence of Mahan and Shoal Creeks, Bibb County, Alabama. Scattered individuals of triangular kidneyshell, orange-nacre mucket, and fine-lined pocketbook continue to be collected from the Cahaba drainage (R. Haddock, Cahaba River Society, pers. comm., 2002; McGregor et al., 2000; Shepard et al., 1994). The river is historic habitat for the Alabama moccasinshell, southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 18. Coosa River (Old River Channel) and tributary, Cherokee, Calhoun, Cleburne Counties, Alabama. Unit 18 encompasses 78 km (48 mi) of river channel in Alabama, including: Coosa River, 18 km (11 mi) extending from the powerline crossing southeast of Maple Grove, Alabama, upstream to Weiss Dam, Cherokee County, Alabama; Terrapin Creek, 53 km (33 mi) extending from its confluence with the Coosa River, Cherokee County, upstream to Cleburne County Road 49, Cleburne County, Alabama; South Fork Terrapin Creek, 7 km (4 mi) from its confluence with Terrapin Creek, upstream to Cleburne County Road 55, Cleburne County, Alabama. The short reach of the Coosa River continues to support a fairly robust population of the southern clubshell, and a few individuals of the fine-lined pocketbook (Herod et al., 2001). The fine-lined pocketbook and southern clubshell have also been recently collected from Terrapin Creek (Feminella and Gangloff, 2000). This area is within the range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 19. Hatchet Creek, Coosa, Clay Counties, Alabama. Unit 19 encompasses 66 km (41 mi) of the Hatchet Creek channel in Alabama, extending from the confluence of Swamp Creek at Coosa County Road 29, Coosa County, Alabama, upstream to Clay County Road 4, Clay County, Alabama. The fine-lined pocketbook occurs within this reach (Feminella and Gangloff, 2000; Pierson, 1992b). Hatchet Creek is within the historic range of the Coosa moccasinshell, southern pigtoe, ovate clubshell, southern clubshell, triangular kidneyshell, upland combshell, and southern acornshell.

Unit 21. Kelly Creek and tributary, Shelby, St. Clair Counties, Alabama. Unit 21 encompasses 34 km (21 mi) of stream channel in Alabama, including: Kelly Creek, 26 km (16 mi) extending from the confluence with the Coosa River, upstream to the confluence of Shoal Creek, St. Clair County, Alabama; Shoal Creek, 8 km (5 mi), from confluence with Kelly Creek, St. Clair County, Alabama, upstream to St. Clair/ Shelby County Line, St. Clair County, Alabama. Kelly/Shoal Creeks continue to support scattered individuals of the fine-lined pocketbook, and the southern clubshell and triangular kidneyshell survive in Kelly Creek (Pierson pers. comm., 1995; Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream complex is historic habitat for the southern pigtoe, Coosa moccasinshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 23. Yellowleaf Creek and tributary, Shelby County, Alabama. Unit 23 encompasses 39 km (24 mi) of stream channel, including: Yellowleaf Creek, 32 km (20 mi), extending from Alabama Highway 25, upstream to Shelby County Road 49; Muddy Prong, 7 km (4 mi), extending from confluence with Yellowleaf Creek, upstream to U.S. Highway 280, Shelby County, Alabama. Yellowleaf and Muddy Prong Creeks are currently inhabited by the fine-lined pocketbook (Feminella and Gangloff, 2000; Gangloff in litt., 2001; Pierson in litt., 2000). Yellowleaf Creek is in the historic range of the Coosa moccasinshell, southern pigtoe, and triangular kidneyshell.

Unit 24. Big Canoe Creek, St. Clair County, Alabama. Unit 24 encompasses 29 km (18 mi) of the Big Canoe Creek channel, extending from its confluence with Little Canoe Creek at the St. Clair/ Etowah County line, St. Clair County, upstream to the confluence of Fall Branch, St. Clair County, Alabama. The southern clubshell, southern pigtoe, and triangular kidneyshell are surviving in low numbers in Big Canoe Creek (Feminella and Gangloff, 2000; Gangloff in litt., 2001). This stream is also historic habitat for the fine-lined pocketbook, ovate clubshell, Coosa moccasinshell, upland combshell, and southern acornshell.

Unit 25. Oostanaula River/Coosawattee River/Conasauga River/Holly Creek, Floyd, Gordon, Whitfield, Murray Counties, Georgia; Bradley, Polk Counties, Tennessee. Unit 25 encompasses 206 km (128 mi) of river and stream channel in Georgia and Tennessee, including: Oostanaula River, 77 km (48 mi) extending from its confluence with the Etowah River, Floyd County, upstream to the confluence of the Conasauga and Coosawattee River, Gordon County, Georgia; Coosawattee River, 15 km (9 mi), from confluence with the Conasauga River, upstream to Georgia State Highway 136, Gordon County, Georgia; Conasauga River, 98 km (61 mi), from confluence with the Coosawattee River, Gordon County, Georgia, upstream through Bradley and Polk Counties, Tennessee, to the Murray County Road 2, Murray County, Georgia; Holly Creek, 16 km (10 mi), from confluence with Conasauga River, upstream to its confluence with Rock Creek, Murray County, Georgia. This extensive riverine reach continues to support small and localized populations of fine-lined pocketbook, southern pigtoe, triangular kidneyshell, Alabama moccasinshell, and Coosa moccasinshell. The triangular kidneyshell survives throughout this unit, while the fine-lined pocketbook, southern pigtoe, and Coosa moccasinshell appear to be currently restricted to the Conasauga River and Holly Creek and the southern clubshell appears restricted to a small 15 km (9 mi) reach of the Conasauga River (Evans, 2001; Johnson and Evans, 2000; Pierson in litt., 1993; Williams and Hughes, 1998). The Alabama moccasinshell is currently known to survive only in the Holly Creek portion of this Unit (Evans, 2001; Johnson and Evans, 2000). The Oostanaula/ Coosawattee/Conasauga Unit also contains historic habitat for the southern clubshell, ovate clubshell, upland combshell, and southern acornshell.

Unit 26. Lower Coosa River, Elmore County, Alabama. Unit 26 encompasses 13 km (8 mi) of the Lower Coosa River channel, extending from Alabama State Highway 111 bridge, upstream to Jordan Dam, Elmore County, Alabama. This river reach is within the historic range of fine-lined pocketbook, southern clubshell, Alabama moccasinshell, Coosa moccasinshell, ovate clubshell, southern pigtoe, triangular kidneyshell, upland combshell, and southern acornshell. (Johnson, 2002; Pierson, 1991a).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the triangular kidneyshell (Ptychobranchus greenii) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Geomorphically stable stream and river channels and banks;

(ii) A flow regime (i.e., the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of mussels and their fish hosts in the river environment;

(iii) Water quality, including temperature, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(iv) Sand, gravel, and/or cobble substrates with low to moderate amounts of fine sediment, low amounts of attached filamentous algae, and other physical and chemical characteristics necessary for normal behavior, growth, and viability of all life stages;

(v) Fish hosts, with adequate living, foraging, and spawning areas for them; and

(vi) Few or no competitive nonnative species present.

Special Management Considerations or Protections

All critical habitat units identified may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, presence of fish hosts, or to prevent or control exotic competing or predaceous species. All of these units are threatened by actions that alter the stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation; and the introduction or augmentation of nonnative species that may compete with or prey on the mussel species inhabiting the units (e.g., Asian clams, zebra or quagga mussels, black carp).

Life History

Feeding Narrative

Adult: All mussels are filter feeders. Oxygen-bearing water and food are drawn into the incurrent siphon, and waste-carrying water is simultaneously passed out the excurrent siphon. The food, mostly detritus (small particles of matter), bacteria and small planktonic (passively floating or drifting) organisms, is filtered from the water by the gills (USFWS, 2000).

Reproduction Narrative

Adult: Freshwater mussel larvae (glochidia) are brooded in the gills of the female and when mature are released into the water where they spend a brief period as obligate parasites on the gills, fins, or other external parts of fish until they drop off to the benthos. Haag and Warren (1997) also noted that it released its glochidia in conglutinates that "...were round and pearl-colored with 2 black eye-spots and strongly resembled fertilized fish eggs." Females were found gravid with mature glochidia in mid April with water temperature of 13 degrees C (Haag and Warren, 1997). Gravid females were observed in March 1994 and April 1996. Glochidia are packaged into conglutinates that mimic small aquatic fly larvae (Hartfield and Hartfield, 1996) or fish eggs (Haag and Warren, 1997). Suitable host fish include Etheostoma bellator (warrior darter), Etheostoma douglasi (Tuskaloosa darter), Percina nigrofaciata (blackbanded darter), and Percina cf. caprodes (logperch) (Haag and Warren, 1997) (NatureServe, 2015). While a few of the thin-shelled species may live only 4 to 10 years, the thicker shelled river species normally survive over a span of 20-40 or more years. Reaching sexual maturity requires more than a year in all species; some of the slower growing species may require 4 or more years (USFWS, 2000).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Unknown (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Habitat Narrative

Adult: This species appears most prevalent in sections of river three feet in depth and having a good current and a firm substrate as opposed to coarse gravel and sand (Parmalee and Bogan, 1998) in shoals and runs of small rivers and large streams (USFWS, 2000). The environmental specificity of this species is unknown and it is highly vulnerable. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls. (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Species Trends:

Unknown (USFWS, 2008)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

The extremely limited range and low numbers of the species make it very vulnerable to actual and potential threats. Isolated imperiled populations in the Mobile River basin are likely vulnerable to random accidents, such as toxic spills, and to naturally catastrophic events, such as droughts and floods, even if land use and human populations were to remain constant within isolated watersheds (USFWS, 2000). This species has experienced a long-term decline of 50-70%. The range extent is 40 - 400 square miles, with an unknown population size. There are 1 - 5 occurrences, 1 - 3 occurrences having good viability/integrity (NatureServe, 2015). The status of the species is unknown, based on the 2007 Recovery Data Call (USFWS, 2008).

Threats and Stressors

Stressor: Competition or predation from nonnative species (USFWS, 2004)
Exposure:
Response:
Consequence:
Narrative: Limited habitat and small population size renders this species vulnerable to competition or predation from nonnative species. The Asian clam, Corbicula fluminea, has invaded all major drainages of the Mobile River Basin, however, little is known of the effects of competitive interaction between Asian clams and native species. Decline and even disappearance of native mussels due to competition with the exotic zebra mussel (Dreissena polymorpha) and the quagga mussel (D. bugensis) have been documented in the Great Lakes and Mississippi River Basin. Although zebra and quagga mussels are not currently known to inhabit the Mobile Basin, the Tennessee-Tombigbee Waterway and commercial and recreational boating offer an avenue of introduction. Another potential threat is the black carp (Mylopharyngodon piceus), a mollusk-eating Asian fish used to control snails in commercial fish farms. If introduced or established in the Mobile River Basin, the black carp is likely to have a considerable impact on native freshwater mussels and snails (USFWS, 2004).

Stressor: Stochastic events (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: All populations of this species are affected by and susceptible to stochastic and chronic events (e.g., spills, drought and/or landuse runoff) (USFWS, 2008).

Stressor: Habitat destruction or modification (USFWS, 2003)
Exposure:
Response:
Consequence:
Narrative: This species and its habitat are adversely affected primarily due to changes in river and stream channels caused by dams (impoundments), dredging, or mining, and historic or episodic pollution events. Riverine mussels are killed during construction of dams, they may be suffocated by sediments that accumulate behind the dams; and the reduced water flow behind dams limits food and oxygen available to mussels. Many fish species that serve as hosts to mussel larvae are also eliminated by dams and impounded waters. Other forms of habitat modification— such as channelization, channel clearing and desnagging (woody debris removal), and gold and gravel mining—caused stream bed scour and erosion, increased turbidity, reduction of groundwater levels, and sedimentation, often resulting in severe local impacts to, and even extirpation of, mussel species. Sedimentation may also eliminate or reduce recruitment of juvenile mussels, and suspended sediments can also interfere with feeding. Water pollution from coal mines, carpet mills, fabric dying mills, large industrial plants, inadequately treated sewage, and land surface runoff also contributed to the demise of the species in certain portions of their historic ranges. Freshwater mussels, especially in their early life stages, are extremely sensitive to many pollutants (e.g., chlorine, ammonia, heavy metals, high concentrations of nutrients) commonly found in municipal and industrial wastewater effluents. Stream discharges from these sources may result in decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry, which may impact mussels or their host fish (USFWS, 2003).

Recovery

Reclassification Criteria:
Reclassification does not appear to be a realistic goal for this species at this time (USFWS, 2000).

Delisting Criteria:
The below recovery criteria describes a recovered species, or a species that should be considered for removal from the Federal Lists of Endangered and Threatened Wildlife and Plants (50 CFR 17). I. At least ten (10) populations exhibit a stable or increasing trend, natural recruitment, and multiple age classes (Factors A and E). 2. At least two (2) populations (as defined in criteria 1) exists in each of the four (4) currently occupied sub-basins: (Coosa, Cahaba, Black Warrior, and Tombigbee) (as defined in Criterion 1) (Factors A and E). 3. Threats have been addressed and/or managed to the extent that the species will be viable into the foreseeable future (Factors A, D, and E) (USFWS, 2019).

Recovery Actions:

- Protect habitat integrity and quality (USFWS, 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS, 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Develop measurable recovery criteria (USFWS, 2008).
- Develop and implement plan to quantify and monitor surviving populations (USFWS, 2008).
- Develop and implement plan to describe and monitor habitat conditions where the species survives (USFWS, 2008).
- Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan (USFWS, 2008).
- Work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate (USFWS, 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: 1. Develop measurable recovery criteria for these mussel species. 2. Develop and implement a plan to quantify and monitor surviving populations. 3. Continue to refine and implement the Mobile River Basin Mollusk Propagation Plan. 4. Continue to work with States to reintroduce hatchery reared mussels into restored habitats, as appropriate. 5. Several changes were noted in this review to taxonomic classification or changes in nomenclature. These changes are detailed by Williams et al. (2017). A need exists to publish and recognize the changes that have occurred since the listing action in the Federal Register. 6. Conduct additional genetic analyses to determine the species status for rayed kidneyshell. If findings confirm species status for both kidneyshell mussels, their protective status should be reassessed under the Endangered Species Act as separate species. 7. Develop and implement a plan to describe and monitor habitat conditions where the mussels survive. 8. Conduct additional toxicological and biological tolerance levels (DO, pH, and temperature, conductivity, etc.) to better assess water quality standards for these imperiled mollusks. 9. Protect water quality within drainages known to support habitat for these mussels through cooperative agreements (e.g., Partners for Fish and Wildlife), conservation land acquisitions (e.g., Cahaba River NWR acquisition boundary, TNC reserves or easements, Forever Wildlife Trust). 10. Work with landowners of priority parcels to identify, fund, and implement management actions to improve water quality. 11. Increase public awareness through outreach materials, festivals, outings, and other methods. (USFWS, 2019a)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin. Final rule. 69 FR 40084 - 40171 (July 1, 2004).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

U.S. Fish and Wildlife Service. 2000. Mobile River Basin Aquatic Ecosystem Recovery Plan. Atlanta, GA. 128 pp.

USFWS 2008. 11 Southeastern Mussels 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Ecological Services Jackson Mississippi.

USFWS. 2004. Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Final Rule. 69 Federal Register 126, July 1, 2004. Pages 40084 - 40171.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (Medionidusparvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell

(Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region Ecological Services, Jackson, Mississippi. 37 pp.

USFWS. 2003. Proposed Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin

Proposed Rule. 68 Federal Register 58

March 26, 2003. Pages 14752 - 14832.

U.S. Fish and Wildlife Service. 2019. Recovery Plan Revision for the Endangered Triangular Kidneyshell (Ptychobranchus greenii). Amendment 1.

USFWS. 2008. Fine-lined Pocketbook (Hamiota altilis), Orange-nacre Mucket (Hamiota perovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa moccasinshell (), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleurobema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pleurobema perovatum), Triangular Kidneyshell (Ptychobranchus greenii), Upland Combshell (Epioblasma metastriata), Southern Acornshell (Epioblasma othcaloogensis)

USFWS. 2019a. Finelined Pocketbook (Hamiota (=Lampsilis) altilis), Orangenacre Mucket (Hamiota (=Lampsilis) preovalis), Alabama moccasinshell (Medionidus acutissimus), Coosa Moccasinshell (Medionidus parvulus), Southern Clubshell (Pleurobema decisum), Dark Pigtoe (Pleuribema furvum), Southern Pigtoe (Pleurobema georgianum), Ovate Clubshell (Pluerobema preovatum), Triangular Kidneyshell (Ptychobranchus greenii). 5-Yeare Review: Summary and Evaluation. 69 pp.

SPECIES ACCOUNT: *Ptychobranchus jonesi* (Southern kidneyshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/10/2012; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A medium-sized, elongate, nearly tubular, brown freshwater mussel. The southern kidneyshell is a small to medium-sized mussel that attains a maximum length of 65 mm. It has a moderately thick, elliptical shell with the dorsal and ventral margins nearly parallel. The shell is very inflated with prominent biangulation on the posterior end. The periostracum is smooth, olive green to blackish in color, sometimes with irregularly distributed green rays. Internally, lateral teeth are curved and thin, and pseudocardinals are compressed. The nacre is bluish-white and iridescent (Johnson, 1967; Williams et al., 2000). The length is 6 cm. (NatureServe, 2015)

Taxonomy

This species was described as Lampsilis jonesi van der Schalie, 1934. It was erroneously considered by Clench and Turner (1956) to be a synonym of Lampsilis (= Villosa) australis Simpson, 1900 (see Johnson, 1967). Athearn (1964) gave characters to distinguish jonesi from australis. Fuller and Bereza (1974) correctly assigned it to the genus Ptychobranchus. Roe (2001) has preliminarily determined the genus to be monophyletic and young, comparatively. (NatureServe, 2015)

Historical Range

The southern kidneyshell is endemic to the Escambia and Yellow river drainages in Alabama, and Choctawhatchee River drainage in Alabama and Florida (Williams and Butler, 1994; Butler, 1989). There are 7 known historic sites in the Escambia River drainage, 2 in the Yellow River drainage, and 14 in the Choctawhatchee River drainage, for a total of only 23 historic sites. (NatureServe, 2015)

Current Range

The only recent Alabama records are from the West Fork of the Choctawhatchee River (Mirarchi et al., 2004) and 6 new sites in the Pea River and 1 in the Choctawhatchee River in 2006-2007 (Gangloff and Hartfield, 2009). Blalock-Herod et al. (2005) noted very severe decline and found live individuals at only 1 historic site within the Choctawhatchee River drainage as well as at sites where the species was found in 1993 (finding none) and found no new sites. (NatureServe, 2015)

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On October 10, 2012, the U.S. Fish and Wildlife Service designated critical habitat for the southern kidneyshell (Ptychobranchus jonesi), under the Endangered Species Act of 1973, as amended (77 FR 61663 - 61719).

Critical Habitat Designation

Critical habitat for the southern kidneyshell is located in GCM1: Lower Escambia River, GCM3: Patsaliga Creek, GCM4: Upper Escambia River, GCM6: Choctawhatchee River and Lower Pea River, and GCM7: Upper Pea River; a total stream length of 1,226 miles.

Unit GCM1: Lower Escambia River Drainage, Florida and Alabama. Unit GCM1 encompasses 558 km (347 mi) of the lower Escambia River mainstem and 12 tributary streams in Escambia and Santa Rosa Counties, FL, and Escambia, Covington, Conecuh, and Butler Counties, AL. The unit consists of the main channel of the EscambiaConecuh River from the confluence of Spanish Mill Creek, Escambia and Santa Rosa counties, FL, upstream 204 km (127 mi) to the Point A Lake dam, Covington County, AL; Murder Creek from its confluence with the Conecuh River, Escambia County, AL, upstream 62 km (38 mi) to the confluence of Cane Creek, Conecuh County, AL; Burnt Corn Creek from its confluence with Murder Creek, Escambia County, AL, upstream 59 km (37 mi) to County Road 20, Conecuh County, AL; Jordan Creek from its confluence with Murder Creek, upstream 5.5 km (3.5 mi) to Interstate 65, Conecuh County, AL; Mill Creek from its confluence with Murder Creek upstream 2.5 km (1.5 mi) to the confluence of Sandy Creek, Conecuh County, AL; Sandy Creek from its confluence with Mill Creek upstream 5.5 km (3.5 mi) to County Road 29, Conecuh County, AL; Sepulga River from its confluence with the Conecuh River upstream 69 km (43 mi) to the confluence of Persimmon Creek, Conecuh County, AL; Bottle Creek from its confluence with the Sepulga River upstream 5.5 km (3.5 mi) to County Road 42, Conecuh County, AL; Persimmon Creek from its confluence with the Sepulga River, Conecuh County, upstream 36 km (22 mi) to the confluence of Mashy Creek, Butler County, AL; Panther Creek from its confluence with Persimmon Creek upstream 11 km (7 mi) to State Route 106, Butler County, AL; Pigeon Creek from its confluence with the Sepulga River, Conecuh and Covington Counties, upstream 89 km (55 mi) to the confluence of Three Run Creek, Butler County, AL; and Three Run Creek from its confluence with Pigeon Creek upstream 9 km (5.5 mi) to the confluence of Spring Creek, Butler County, AL. Unit GCM1 is within the geographical area occupied at the time of listing (2012) for the round ebonyshell, southern kidneyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Escambia River system is within the species' historical range, and we consider it essential to the southern kidneyshell's conservation due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. The unit currently supports populations of round ebonyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, cooccur with these five species. A diverse fish fauna, including potential fish host(s) for the fuzzy pigtoe, are known from the Escambia River drainage, indicating the potential presence of PCE 5. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to two upstream impoundments. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM3: Patsaliga Creek Drainage, Alabama. Unit GCM3 encompasses 149 km (92 mi) of Patsaliga Creek and two tributary streams in Covington, Crenshaw, and Pike Counties, AL, within the Escambia River basin. The unit consists of the Patsaliga Creek mainstem from its confluence with Point A Lake at County Road 59, Covington County, AL, upstream 108 km (67 mi) to

Crenshaw County Road 66-Pike County Road 1 (the creek is the county boundary), AL; Little Patsaliga Creek from its confluence with Patsaliga Creek upstream 28 km (17 mi) to Mary Daniel Road, Crenshaw County, AL; and Olustee Creek from its confluence with Patsaliga Creek upstream 12 km (8 mi) to County Road 5, Pike County, AL. Unit GCM3 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Patsaliga Creek system is within the species' historic range. We consider it essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the Patsaliga Creek drainage, indicating the potential presence of PCE 5. Prior to construction of the Point A Lake and Gantt Lake dams in 1923, Patsaliga Creek drained directly to the Conecuh River main channel. It now empties into Point A Lake and is effectively isolated from the main channel by the dams. The dams are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM4: Upper Escambia River Drainage, Alabama. Unit GCM4 encompasses 137 km (85 mi) of the Conecuh River mainstem and two tributary streams in Covington, Crenshaw, Pike, and Bullock Counties, AL, within the Escambia River drainage. The unit consists of the Conecuh River from its confluence with Gantt Lake reservoir at the Covington-Crenshaw County line upstream 126 km (78 mi) to County Road 8, Bullock County, AL; Beeman Creek from its confluence with the Conecuh River upstream 6.5 km (4 mi) to the confluence of Mill Creek, Pike County, AL; and Mill Creek from its confluence with Beeman Creek, upstream 4.5 km (3 mi) to County Road 13, Pike County, AL. Unit GCM4 is is within the geographical area occupied at the time of listing (2012) Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Conecuh River is within the species' historic range, and we consider it to be essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species requiring similar PCEs co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the upper Escambia River drainage, indicating the potential presence of PCE 5. The Point A Lake and Gantt Lake dams on the Conecuh River mainstem are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM5: Yellow River Drainage, Florida and Alabama. Unit GCM5 encompasses 247 km (153 mi) of the Yellow River mainstem, the Shoal River mainstem, and three tributary streams in Santa Rosa, Okaloosa, and Walton Counties, FL, and Covington County, AL. The unit consists of the Yellow River from the confluence of Weaver River (a tributary located 0.9 km (0.6 mi), downstream of State Route 87), Santa Rosa County, FL, upstream 157 km (97 mi) to County Road 42, Covington County, AL; the Shoal River from its confluence with the Yellow River, Okaloosa

County, FL, upstream 51 km (32 mi) to the confluence of Mossy Head Branch, Walton County, FL; Pond Creek from its confluence with Shoal River, Okaloosa County, FL, upstream 24 km (15 mi) to the confluence of Fleming Creek, Walton County, FL; and Five Runs Creek from its confluence with the Yellow River upstream 15 km (9.5 mi) to County Road 31, Covington County, AL. Unit GCM5 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell was known from the Yellow River drainage; however, its occurrence in the basin is based on the collection of one specimen in 1919 from Hollis Creek in Alabama. We believe this single, historical record is not sufficient to consider this unit as essential to the conservation of the southern kidneyshell. Therefore, we are not designating Unit GCM5 as critical habitat for the southern kidneyshell at this time. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna are known from the Yellow River drainage, indicating the potential presence of PCE 5.

Unit GCM6: Choctawhatchee River and Lower Pea River Drainages, Florida and Alabama Unit GCM6 encompasses 897 km (557 mi) of the Choctawhatchee River mainstem, the lower Pea River mainstem, and 29 tributary streams in Walton, Washington, Bay, Holmes, and Jackson Counties, FL, and Geneva, Coffee, Dale, Houston, Henry, Pike, and Barbour Counties, AL. The unit consists of the Choctawhatchee River from the confluence of Pine Log Creek, Walton County, FL, upstream 200 km (125 mi) to the point the river splits into the West Fork Choctawhatchee and East Fork Choctawhatchee rivers, Barbour County, AL; Pine Log Creek from its confluence with the Choctawhatchee River, Walton County, upstream 19 km (12 mi) to the confluence of Ditch Branch, Washington and Bay Counties, FL; an unnamed channel forming Cowford Island from its downstream confluence with the Choctawhatchee River upstream 3 km (2 mi) to its upstream confluence with the river, Washington County, FL; Crews Lake from its western terminus 1.5 km (1 mi) to its eastern terminus, Washington County, FL (Crews Lake is a relic channel southwest of Cowford Island, and is disconnected from the Cowford Island channel, except during high flows); Holmes Creek from its confluence with the Choctawhatchee River, Washington County, FL, upstream 98 km (61 mi) to County Road 4, Geneva County, AL; Alligator Creek from its confluence with Holmes Creek upstream 6.5 km (4 mi) to County Road 166, Washington County, FL; Bruce Creek from its confluence with the Choctawhatchee River upstream 25 km (16 mi) to the confluence of an unnamed tributary, Walton County, FL; Sandy Creek from its confluence with the Choctawhatchee River, Walton County, FL, upstream 30 km (18 mi) to the confluence of West Sandy Creek, Holmes and Walton County, FL; Blue Creek from its confluence with Sandy Creek, upstream 7 km (4.5 mi) to the confluence of Goose Branch, Holmes County, FL; West Sandy Creek from its confluence with Sandy Creek, upstream 5.5 km (3.5 mi) to the confluence of an unnamed tributary, Walton County, FL; Wrights Creek from its confluence with the Choctawhatchee River, Holmes County, FL, upstream 43 km (27 mi) to County Road 4, Geneva County, AL; Tenmile Creek from its confluence with Wrights Creek upstream 6 km (3.5 mi) to the confluence of Rice Machine Branch, Holmes County, FL; West Pittman Creek from its confluence with the Choctawhatchee River upstream 6.5 km (4 mi) to Fowler Branch, Holmes County, FL; East Pittman Creek from its confluence with the Choctawhatchee River upstream 4.5 km (3 mi) to County Road 179, Holmes County, FL; Parrot Creek from its confluence with the Choctawhatchee River upstream 6 km (4 mi) to Tommy Lane, Holmes County, FL; the Pea River from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 91 km (57 mi) to the Elba Dam, Coffee County, AL; Limestone Creek from its confluence with the Pea River upstream 8.5 km (5 mi) to Woods Road, Walton County, FL; Flat Creek from the Pea River upstream 17 km (10 mi) to the confluence of Panther Creek, Geneva County, AL; Eightmile Creek from its confluence with Flat Creek, Geneva County, AL, upstream 15 km (9 mi) to the confluence of Dry Branch (first tributary upstream of County Road 181), Walton County, FL; Corner Creek from its confluence with Eightmile Creek upstream 5 km (3 mi) to State Route 54, Geneva County, AL; Natural Bridge Creek from its confluence with Eightmile Creek Geneva County, AL, upstream, 4 km (2.5 mi) to the Covington-Geneva County line, AL; Double Bridges Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 46 km (29 mi) to the confluence of Blanket Creek, Coffee County, AL; Claybank Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 22 km (14 mi) to the Fort Rucker military reservation southern boundary, Dale County, AL; Claybank Creek from the Fort Rucker military reservation northern boundary, upstream 6 km (4 mi) to County Road 36, Dale County, AL; Steep Head Creek from the Fort Rucker military reservation western boundary, upstream 4 km (2.5 mi) to County Road 156, Coffee County, AL; Hurricane Creek from its confluence with the Choctawhatchee River upstream 14 km (8.5 mi) to State Route 52, Geneva County, AL; Little Choctawhatchee River from its confluence with the Choctawhatchee River, Dale and Houston Counties upstream 20 km (13 mi) to the confluence of Newton Creek, Houston County, AL; Panther Creek from its confluence with the Little Choctawhatchee River, upstream 4.5 km (2.5 mi) to the confluence of Gilley Mill Branch, Houston County, AL; Bear Creek from its confluence with the Little Choctawhatchee River, upstream 5.5 km (3.5 mi) to County Road 40 (Fortner Street), Houston County, AL; West Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 54 km (33 mi) to the fork of Paul’s Creek and Lindsey Creek, Barbour County, AL; Judy Creek from its confluence with West Fork Choctawhatchee River upstream 17 km (11 mi) to County Road 13, Dale County, AL; Sikes Creek from its confluence with West Fork Choctawhatchee River, Dale County, AL, upstream 8.5 km (5.5 mi) to State Route 10, Barbour County, AL; Paul’s Creek from its confluence with West Fork Choctawhatchee River upstream 7 km (4.5 mi) to one mile upstream of County Road 20, Barbour County, AL; Lindsey Creek from its confluence with West Fork Choctawhatchee River upstream 14 km (8.5 mi) to the confluence of an unnamed tributary, Barbour County, AL; an unnamed tributary to Lindsey Creek from its confluence with Lindsey Creek upstream 2.5 km (1.5 mi) to 1.0 mile upstream of County Road 53, Barbour County, AL; and East Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 71 km (44 mi) to County Road 71, Barbour County, AL. Unit GCM6 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the Choctawhatchee River, including a potential fish host for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. Not included in this unit are two oxbow lakes now disconnected from the Choctawhatchee River main channel in Washington County, Florida. Horseshoe Lake has a record of southern kidneyshell from 1932, and Crawford Lake has records of Choctaw bean and tapered pigtoe from 1934. It is possible these oxbow lakes had some connection to the main channel when the collections were made over 75 years ago. The three species are not currently known to occur in Horseshoe or Crawford lakes, and we do not consider them essential to the conservation of the southern kidneyshell, Choctaw bean, or tapered pigtoe. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to the Elba Dam on the Pea River mainstem. As discussed in Summary of

Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM7: Upper Pea River Drainage, Alabama. Unit GCM7 encompasses 234 km (145 mi) of the upper Pea River mainstem and six tributary streams in Coffee, Dale, Pike, Barbour, and Bullock Counties, AL. This unit is within the Choctawhatchee River basin and includes the stream segments upstream of the Elba Dam. The unit consists of the Pea River from the Elba Dam, Coffee County, upstream 123 km (76 mi) to State Route 239, Bullock and Barbour Counties, AL; Whitewater Creek from its confluence with the Pea River, Coffee County upstream 45 km (28 mi) to the confluence of Walnut Creek, Pike County, AL; Walnut Creek from its confluence with Whitewater Creek upstream 14 km (9 mi) to County Road 26, Pike County, AL; Big Creek (Coffee County) from its confluence with Whitewater Creek, Coffee County, upstream 30 km (18 mi) to the confluence of Smart Branch, Pike County, AL; Big Creek (Barbour County) from its confluence with the Pea River upstream 10 km (6 mi) to the confluence of Sand Creek, Barbour County, AL; Pea Creek from its confluence with the Pea River upstream 6 km (4 mi) to the confluence of Hurricane Creek, Barbour County, AL; and Big Sandy Creek from its confluence with the Pea River upstream 6.5 km (4 mi) to County Road 14, Bullock County, AL. Unit GCM7 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the upper Pea River, including potential fish host(s) for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. The Elba Dam on the Pea River mainstem is a barrier to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological feature includes the absence of potential host fishes.

Primary Constituent Elements/Physical or Biological Features

Within the critical habitat units, the primary constituent elements of the physical or biological features essential to the conservation of the southern kidneyshell consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to this mussel and its habitat are pervasive and common in all of the units that are designated as critical habitat These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas designated as critical habitat are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species. Adults are detritivores, while larvae are parasitic (NatureServe, 2015). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column. Juveniles typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994, pp. 200–221; Gatenby et al. 1996, p. 604) (USFWS, 2012).

Reproduction Narrative

Adult: This species is probably bradytictic (long-term brooder), as are congeners in the Cumberlandian region. The genus is known for its characteristically pleated (when gravid) marsupium (NatureServe, 2015). Females are gravid from autumn to the following spring or summer. Host fish for the southern kidneyshell are currently unknown; however, darters serve as primary glochidial hosts to other members of the genus Ptychobranchus (Luo 1993, p. 16; Haag and Warren 1997, p. 580) (USFWS, 2012). A study of Southern Kidneyshell early life history has provided new information regarding its reproductive biology. Two females collected from the Pea River in January 2015 released conglutinates (packets of larvae) daily over four months, from early February to early June (McLeod et al. 2017). The extremely adhesive conglutinates attach immediately to any surface. The conglutinates resembled simullid (black fly) larvae and fish eggs and were released with both forms loosely attached 26% of the time; more frequently, the egg (41%) and larva (33%) forms were released as separate segments (McLeod et al. 2017). The total calculated fecundity was 196,183 glochidia for the larger (56.1 mm) mussel and 53,425 for the smaller (37.4 mm) mussel (McLeod et al. 2017). Southern Kidneyshell glochidia transformed on three darter species in inoculation-bath and conglutinate-feeding host trials: Blackbanded Darters (Percina nigrofasciata), Brown Darters (Etheostoma edwini), and Swamp Darters (Etheostoma fusiforme) (McLeod et al. 2017). Blackbanded Darters were the primary hosts in both trials. The encystment period lasted from 21 to 39 days. Twenty-five other fish species from 11 families were also tested, but none successfully transformed larvae, indicating the Southern Kidneyshell is a host specialist and dependent on darters for reproduction (McLeod et al. 2017). Blackbanded Darters are one of the most abundant darter species in Coastal Plain streams (Kuehne and Barbour 1983, Robins et al. 2018). However, reduced gene flow in darter-using mussel species suggests that parasitized darters rarely migrate long distances between isolated mussel populations (Jones et al. 2015). Thus, the Southern Kidneyshell may be unable to disperse long distances or recolonize areas from which it has been extirpated (USFWS, 2022).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (USFWS, 2012; see threats)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: The southern kidneyshell is known from medium-sized creeks to rivers in silty sand substrates with slow current and woody debris (Williams and Butler, 1994). It has also been located in claystone pockets with sand (Blalock-Herod et al., 2005). The environmental specificity of this species is narrow and it is highly vulnerable to threats from siltation, pollution, eutrophication, channelization, impoundment, collection, drought and water withdrawal, competition from invasive non-native mussels, and changes to larval host fish populations. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). A recent status survey in the Choctawhatchee basin in Alabama found its preferred habitat to be stable substrates near bedrock outcroppings (Gangloff and Hartfield 2009, p. 25) (USFWS, 2012).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate although some passive movement downstream may occur during high flows. Dispersal occurs while the glochidia are encysted on their host (probably a fish).This species is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of >90% (NatureServe, 2015)

Species Trends:

Declining (NatureServe, 2015)

Number of Populations:

5 extant (USFWS, 2022)

Population Size:

250 - 1000 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Freshwater mussels are inherently vulnerable to threats from siltation, pollution, eutrophication, channelization, impoundment, collection, drought and water withdrawal, competition from invasive non-native mussels, and changes to larval host fish populations. Disappearance of host fish is a potential problem within the rivers in which the species occurs. Also, severe habitat fragmentation has placed extreme limitations on dispersal capabilities of this species that currently may have no remaining viable populations left. Blalock-Herod et al. (2005) noted a very severe decline; they found live individuals at only 1 historic site within the Choctawhatchee River drainage as well as other sites where the species was found in 1993 (finding none), and found no new sites. It was historically widespread in the Choctawhatchee River drainage in Alabama and Florida, with a few records from the Escambia and Yellow River drainages, but is now known from only 3 sites (Williams et al., 2008). This species has experienced a long-term decline of >90%. The range extent is 100 - 400 square miles, with and estimated population size of 250 - 1,000 individuals. There are up to 20 occurrences, with 0 -3 having good viability/integrity. Recent status surveys indicated that this species has experienced severe range reductions and occurs in low abundance within its limited range (NatureServe, 2015). Currently, the species occurs in one stream system in the Escambia River basin and four widely separated stream systems in the Choctawhatchee River basin, which may represent disjunct populations. The Southern Kidneyshell appears to be nearly extirpated in the Escambia River basin and declining in the Choctawhatchee basin. Southern Kidneyshell current (2000–2021) occurrences are discussed below and summarized by subbasin in Appendix A (USFWS, 2022).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The primary cause of the decline of these eight mussels has been the modification and destruction of their stream and river habitat, with sedimentation as the leading cause. Sediments have been shown to abrade or suffocate periphyton (organisms attached to underwater surfaces); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters 1995, pp. 173– 175). Activities such sand and gravel mining, the removal of large woody material, off-road vehicles use, and land use changes are known to cause channel destabilization. Activities that destabilize stream beds and channels can result in drastic alterations to stream geomorphology and consequently to the stream's ecosystem. Land use activities such as land clearing and development can cause channel instability by accelerating stormwater runoff into streams. Increased runoff rates can result in bank erosion and bed scour (Brim Box and Mossa 1999, p. 103), and can lead to channel incision (Booth 1990, p. 407; Doyle et al. 2000, p. 157, 175).

Stressor: Impoundments (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Dams eliminate or reduce river flow within impounded areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, affect normal flood patterns, and block upstream and downstream movement of mussels and their host fishes (Bogan 1993, p. 604; Vaughn and Taylor 1999, pp. 915–917; Watters 1999, pp. 261–264; McAllister et al. 2000, p. iii; Marcinek et al. 2005, pp. 20–21). Downstream of dams, mollusk declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels, water temperatures, and changes in resident fish assemblages (Williams et al. 1993, p. 7; Neves et al. 1997, pp. 63–64; Watters 1999, pp. 261– 264; Marcinek et al. 2005, pp. 20–21) (USFWS, 2012).

Stressor: Pollution (USFWS, 2012)
Exposure:
Response:

Consequence:
Narrative: Nonpoint-source pollution from land surface runoff originates from virtually all land use activities and includes sediments, fertilizer, herbicide and pesticide residues; animal wastes; septic tank leakage and gray water discharge; and oils and greases. Nutrients, usually phosphorus and nitrogen, may emanate from agricultural fields, residential lawns, livestock feedlots, poultry houses, and leaking septic tanks in levels that result in eutrophication and reduced oxygen levels in small streams (USFWS, 2012).

Stressor: Stochastic events (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Although floods and droughts are a natural part of the hydrologic processes that occur in these river systems, these events may contribute to the further decline of mussel populations suffering the effects of other threats. There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin et al. 2002, p. 6074; Golladay et al. 2004, p. 504; Cook et al. 2004, p. 1015). Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in stream temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions. The linear nature its habitat, reduced range, and small population size makes This species vulnerable to contaminant spills (USFWS, 2012).

Stressor: Small, isolated populations (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153) (USFWS, 2012).

Stressor: Nonindigenous species (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The Asian clam (Corbicula fluminea) may pose a direct threat to native mussels, particularly as juveniles, as a competitor for resources such as food, nutrients, and space (Neves and Widlak 1987, p. 6). Dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles, and may actively disturb sediments, reducing habitable space for juvenile native mussels, or displacing them downstream (Strayer 1999, p. 82; Yeager et al. 2000, pp. 255–256). The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations. Biologists working in the Florida portions of these drainages have observed a correlation between the increase in flathead catfish numbers and a decrease in numbers of other native fish species, particularly of bullhead catfish (Ameiurus sp.) and redbreast sunfish (Lepomis auritus) (Strickland 2010 pers. comm.) (USFWS, 2012).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES These seven species do not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities, which are included below. Recovery Activities a. Encourage the protection and establishment of wide riparian buffer zones along all streams containing or draining into the historical ranges of these species. Buffers of at least 300 feet in width and consisting of native forest are considered the most protective and effective. A greater width may be necessary to effectively buffer storm water runoff from urban and suburban lands, cultivated fields, and timber harvest operations. b. Restore and increase in-stream habitat and stream connectivity through conservation actions, including but not limited to removing artificial fish migration barriers, bank stabilization, riparian buffer maintenance or augmentation, improving water quality downstream of impoundments, and adherence to BMPs. c. Work with state and federal agencies and private organizations to promote land and water stewardship awareness (e.g., Soil and Water Conservation Districts, Natural Resource Conservation Service (NRCS), State Forestry Commissions, private industry groups, environmental groups, etc.). d. Develop programs and outreach materials to increase public awareness of these species and explain the benefits of protecting stream ecosystems. Monitoring and Research Activities a. Conduct status survey for Round Ebonyshell in the Conecuh River and document habitat conditions. b. Conduct surveys in under sampled portions of their ranges to examine the species' status and habitat conditions. c. Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. d. Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, and age-specific survival. e. Use eDNA as a detection tool to provide up-to-date distributional information, especially for rare or cryptic species like Southern Kidneyshell. Use assays to confirm presence in historical reaches and detect previously unknown populations. f. Conduct long-term monitoring studies of stream thermal regimes, especially during summer low flow conditions. g. Prepare a comprehensive threats assessment that identifies and maps existing and potential threats within the watersheds and identifies activities or practices that may affect the seven mussels or their habitats. Use the assessment to develop SSAs and recovery plans for the species. h. Model future precipitation, temperature, and flow scenarios in the basins to examine the impacts of climate change and consumptive uses. Use the assessment to develop SSAs and recovery plans for the species. i. Model future sea level and flow scenarios to analyze the effects of saltwater encroachment in the lower mainstems during high tide and storm surge events. Use the assessment to develop SSAs and recovery plans for the species. j. Research important life-history traits, such as host fish use, growth, longevity, age at maturity, and fecundity, and incorporate the results into management and protection actions. All partners should be aware of research efforts and results to facilitate the immediate application of results. k. Determine temperature and contaminant sensitivity for each life-stage, and develop recommendations for EPA and state water quality criteria to protect and enhance habitat. l. Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans. m. Study the life history and identify the host fish of the Southern Sandshell, Choctaw Bean, and Round Ebonyshell (USFWS, 2022).

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 FR 61663 - 61719 (October 10, 2012).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

SPECIES ACCOUNT: *Ptychobranchus subtentum* (Fluted kidneyshell)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/28/2013; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

This is a relatively large freshwater mussel. Shape of the shell is roughly oval elongate, and solid, relatively heavy valves are moderately inflated. A series of flutings (corrugations) characterize the posterior slope. Shell texture is smooth and somewhat shiny in young specimens, becoming more dull with age. Shell color is greenish yellow, becoming brownish with age, with several broken, wide green rays. Internally, the pseudocardinal teeth are stumpy and triangular in shape. Lateral teeth are heavy. Color of the nacre is bluish white to dull white with a wash of salmon in the beak cavity (Parmalee and Bogan, 1998). The length is 13 cm. (NatureServe, 2015)

Taxonomy

Lee (2008) correctly notes that in keeping with the ICZN and proper nomenclatural gender, this species should be rendered Ptychobranchus subtentus. (NatureServe, 2015)

Historical Range

Historically, this species occurred in the Cumberland River main stem from below Cumberland Falls in southeastern Kentucky downstream through the Tennessee portion of the river to the vicinity of the Kentucky-Tennessee State line. In the Tennessee River mainstem it occurred from eastern Tennessee to western Tennessee. Records are known from approximately 16 Cumberland River tributaries (Horse Lick Creek, Middle Fork Rockcastle River, Rockcastle River, Buck Creek, Rock Creek, Kennedy Creek, Little South Fork, Big South Fork, Pitman Creek, Otter Creek, Wolf River, West Fork Obey River, Obey River, Caney Fork, South Harpeth River, and West Fork Red River). Undocumented, but now lost, populations assuredly occurred in other Cumberlandian Region tributary systems (USFWS, 2001). Also from upper Cumberland and Tennessee Rivers, ranging downstream to Muscle Shoals in the Tennessee River but not reported from Alabama since impoundment of Tennessee River (Mirarchi et al., 2004). (NatureServe, 2015)

Current Range

The fluted kidneyshell is restricted to the Cumberland (in Kentucky and Tennessee) and Tennessee (in Alabama, Tennessee, and Virginia) River systems. It is known from 21 Tennessee River system tributaries, including the South Fork Powell River, Powell River, Indian Creek, Little River, Clinch River, Copper Creek, Big Moccasin Creek, North Fork Holston River, Middle Fork Holston River, South Fork Holston River, Holston River, Nolichucky River, West Prong Little Pigeon River, Little Tennessee River, Hiwassee River, Flint River, Limestone Creek, Elk River, Shoal Creek, Duck River, and Buffalo River. Currently, it is limited to nine streams in the Cumberland River system and seven streams in the Tennessee River system. (NatureServe, 2015)

Critical Habitat Designated

Yes; 9/26/2013.

Legal Description

On September 26, 2013, the U.S. Fish and Wildlife Service (Service), designated critical habitat for the fluted kidneyshell (Ptychobranchus subtentum) under the Endangered Species Act of 1973, as amended (78 FR 59555 - 59620).

Critical Habitat Designation

Approximately 2,218 rkm (1,380 rmi) is designated in Alabama, Kentucky, Mississippi, Tennessee, and Virginia as critical habitat. 24 critical habitat units encompassing approximately 1,899 rkm (1,181 rmi) of stream channel are designated in Alabama, Kentucky, Tennessee, and Virginia. The 24 areas designated as critical habitat are as follows: (1) Horse Lick Creek, KY; (2) Middle Fork Rockcastle River, KY; (3) Rockcastle River, KY; (4) Buck Creek, KY; (5) Rock Creek, KY; (6) Little South Fork Cumberland River, KY; (7) Big South Fork Cumberland River, KY, TN; (8) Wolf River and Town Branch, TN; (9) West Fork Obey River, TN; (10) Indian Creek, VA; (11) Little River [tributary to the Clinch River], VA; (12) North Fork Holston River, VA; (13) Middle Fork Holston River, VA; (14) Big Moccasin Creek, VA; (15) Copper Creek, VA; (16) Clinch River, TN, VA; (17) Powell River, TN, VA; (18) Nolichucky River, TN; (19) Holston River, TN; (20) French Broad River, TN; (21) Hiwassee River, TN; (22) Elk River, AL, TN; (23) Duck River, TN; and (24) Buffalo River, TN.

Unit FK1: Horse Lick Creek, Rockcastle and Jackson Counties, Kentucky. Unit FK1 encompasses approximately 19 rkm (12 rmi) of Horse Lick Creek, in Rockcastle and Jackson Counties, KY. It includes the mainstem of Horse Lick Creek from its confluence with the Rockcastle River upstream to Clover Bottom Creek. The unit is within the Cumberland River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the fluted kidneyshell at the time of listing. This unit is located almost entirely on private lands; however, approximately 16 rkm (10 rmi) are federal lands within the DBNF. Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004a, pp. 1– 14). The channel within Unit FK1 is relatively stable, with an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish host(s) for the fluted kidneyshell, are known from this unit (PCE 5). Within Unit FK1, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects associated with legacy coal mines and coal mining activities, silviculture-related activities, natural gas and oil exploration activities in headwater reaches, illegal off-road vehicle use and other recreational activities, and nonpoint source pollution originating in headwater reaches.

Unit FK2: Middle Fork Rockcastle River, Jackson County, Kentucky. Unit FK2 includes 12.5 rkm (7.7 rmi) of the Middle Fork Rockcastle River from its confluence with the Rockcastle River upstream to its confluence with Indian Creek and Laurel Fork in Jackson County, KY. The unit is within the Cumberland River system and is occupied critical habitat for the fluted kidneyshell. About half of this unit (approximately 6 rkm (4 rmi)) is in public ownership (DBNF), and half is in private ownership. Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004a, pp. 1–14). The channel within Unit FK2 is relatively stable and has an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects caused by resource extraction (coal mining, silviculture, natural gas and oil exploration activities), agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, illegal off-road vehicle use, nonpoint source pollution arising from a wide variety of human activities, and potentially canopy loss caused by infestations of the hemlock woolly adelgid, Adelges tsugae, an invasive pest threatening eastern hemlock trees (Tsuga canadensis) in the eastern United States. Hemlocks are an important component of riparian vegetation throughout the range of the two mussels.

Unit FK3: Rockcastle River, Pulaski, Laurel, and Rockcastle Counties, Kentucky. Unit FK3 includes approximately 70 rkm (43 rmi) of the Rockcastle River from the backwaters of Lake Cumberland near its confluence with Cane Creek along the Laurel and Pulaski County line, KY, upstream to its confluence with Horse Lick Creek along the Laurel and Rockcastle County line, KY. The unit is within the Cumberland River system and is considered unoccupied by the fluted kidneyshell at the time of listing, but within the species' historical range. Live fluted kidneyshell have not been collected within Unit FK3 since 1911; however, it persists in adjacent tributaries such as Horse Lick Creek and shell material has been found as recently as 1985 (Wilson and Clark 1914 and Thompson 1985 in Cicerello 1993, p. 12). In 2010, surveys of the Rockcastle River showed that the river had a diverse mussel fauna, including the federally endangered Cumberland bean (McGregor 2010, unpubl. data). We consider this unit essential for the conservation of the fluted kidneyshell due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. Therefore, this unit is designated as unoccupied critical habitat for the fluted kidneyshell. A portion of this unit (approximately 12 rkm (7 rmi)) is in private ownership, but the majority is in public ownership (DBNF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004a, pp. 1– 14).

Unit FK4: Buck Creek, Pulaski County, Kentucky. Unit FK4 includes approximately 61 rkm (38 rmi) of Buck Creek from State Route 192 upstream to Route 328, Pulaski County, KY. The unit is within the Cumberland River basin and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. A portion of this unit (1.3 rkm (0.8 rmi)) is in public ownership (DBNF), but the majority is in private ownership. Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004a, pp. 1– 14). The unit completely overlaps existing critical habitat for the oyster mussel and Cumberlandian combshell (69 FR 53136). The channel within Unit FK4 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish host(s) for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects associated with instream gravel mining, silviculture-related activities, illegal off-road vehicle use and other recreational activities, and nonpoint source pollution from agricultural and developmental activities.

Unit FK5: Rock Creek, McCreary County, Kentucky. Unit FK5 includes approximately 19 rkm (12 rmi) of Rock Creek from its confluence with White Oak Creek upstream to the low water crossing at rkm 25.6 (rmi 15.9) in McCreary County, KY. The unit is within the Cumberland River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. A portion of this unit (1.5 rkm (0.9 rmi)) is in private ownership, but the majority is in public ownership (DBNF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004a, pp. 1–14). The unit completely overlaps existing critical habitat for the Cumberland elktoe (69 FR 53136). The channel within Unit FK5 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish host(s) for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects caused by resource extraction (coal mining, silviculture, natural gas and oil exploration activities), agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, illegal off-road vehicle use, nonpoint source pollution arising from a wide variety of human activities, and potentially canopy loss caused by infestations of the hemlock woolly adelgid.

Unit FK6: Little South Fork Cumberland River, McCreary and Wayne Counties, Kentucky. Unit FK6 includes 65.5 rkm (40.7 rmi) of the Little South Fork Cumberland River from its confluence with the Big South Fork Cumberland River, where it is the dividing line between Wayne and McCreary Counties, upstream to its confluence with Dobbs Creek in Wayne County, KY. The unit is within the Cumberland River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. A portion of this unit (4.4 rkm (2.7 rmi)) is in public ownership (DBNF), but the majority is in private ownership. Land and resource management decisions and activities within the DBNF are guided by DBNF’s LRMP (USFS 2004a, pp. 1–14). The channel within Unit FK6 is relatively stable, with an abundance of riffle habitats (PCE 1), relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish host(s) for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects caused by resource extraction (coal mining, silviculture, natural gas and oil exploration activities), agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, illegal off-road vehicle use, nonpoint source pollution arising from a wide variety of human activities, and potentially canopy loss caused by infestations of the hemlock woolly adelgid.

Unit FK7: Big South Fork Cumberland River, Fentress, Morgan, and Scott Counties, Tennessee, and McCreary County, Kentucky. Unit FK7 includes a combined total of approximately 92 rkm (57 rmi) of the Big South Fork of the Cumberland River, Clear Fork of the New River, and the New River in Tennessee and Kentucky. Unit FK7 includes approximately 45 rkm (28 rmi) of the Big South Fork Cumberland River from its confluence with Laurel Crossing Branch downstream of Big Shoals, McCreary County, KY, upstream to its confluence with Clear Fork and of the New River, Scott County, TN. This unit also includes 32.3 rkm (20.0 rmi) of Clear Fork from its confluence with the Big South Fork and New River in Scott County, TN, upstream to its confluence with Crooked Creek along the Fentress and Morgan County line, TN. This unit also includes 14.7 rkm (9.1 rmi) of the New River from its confluence with the Big South Fork upstream to the Highway 27 Bridge crossing in Scott County, TN. The unit is within the Cumberland River system and is designated as critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. A portion of this unit (92 rkm (57 rmi)) has been designated as critical habitat for the Cumberlandian combshell, oyster mussel, and Cumberland elktoe (69 FR 53136). This unit is located almost entirely on federal lands within the BSFNRRA. Land and resource management decisions and activities within the BSFNRRA are guided by the National Park Service General Management Plan, Field Management Plan, and Draft NonFederal Oil and Gas Management Plan (NPS 2005, entire; NPS 2006, pp. 1–12; NPS 2011, entire). The channel within Unit FK7 is relatively stable, with relatively silt-free sand and gravel substrates (PCE 2) and adequate instream flows (PCE 3). A diverse fish fauna, including fish host(s) for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects caused by resource extraction (coal mining, silviculture, natural gas and oil exploration activities), lack of adequate riparian buffers, construction and maintenance of roads, recreational horse riding, illegal off-road vehicle use, nonpoint source pollution arising from a wide variety of human activities, and potential canopy loss caused by infestations of the hemlock woolly adelgid.

Unit FK8: Wolf River and Town Branch, Pickett and Fentress Counties, Tennessee. Unit FK8 includes 41.0 rkm (25.5 rmi) of the Wolf River from its inundation at Dale Hollow Lake in Pickett County, TN, upstream to its confluence with Delk Creek in Fentress County, TN, and 3.4 rkm (2.0 rmi) of Town Branch from its confluence with Wolf River upstream to its headwaters in Pickett County, TN. The unit is within the Cumberland River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. A portion of this unit (6 rkm (4 rmi)) is in public ownership (U.S. Army Corps of Engineers lands adjacent to Dale Hollow Reservoir and Sgt. Alvin C. York State Historic Park), but the majority is in private ownership. The channel within Unit FK8 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2) and adequate instream flows (PCE 3). A diverse fish fauna, including fish host(s) for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects associated with coal mining, silviculture-related activities, natural gas and oil exploration activities in headwater reaches, agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, off-road vehicle use and other recreational activities, nonpoint source pollution originating in headwater reaches, and potential canopy loss caused by infestations of the hemlock woolly adelgid.

Unit FK9: West Fork Obey River, Overton County, Tennessee. Unit FK9 includes approximately 19 rkm (12 rmi) of the West Fork Obey River from the Highway 52 Bridge crossing upstream to its confluence with Dry Hollow Creek in Overton County, TN. The unit is within the Cumberland River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The channel within Unit FK9 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish host(s) for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects associated with coal mining, silviculture-related activities, natural gas and oil exploration activities in headwater reaches, off-road vehicle use and other recreational activities, agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, nonpoint source pollution originating in headwater reaches, and potential canopy loss caused by infestations of the hemlock woolly adelgid.

Unit FK10: Indian Creek, Tazewell County, Virginia. Unit FK10 includes 6.7 rkm (4.2 rmi) of Indian Creek from its confluence with the Clinch River upstream to the fourth Norfolk Southern Railroad crossing at Van Dyke in Tazewell County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The unit completely overlaps critical habitat for the Cumberlandian combshell, rough rabbitsfoot, purple bean, and oyster mussel (69 FR 53136). The channel within Unit FK10 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects associated with residential development, coal mining, silviculturerelated activities, natural gas and oil exploration activities in headwater reaches, illegal off-road vehicle use and other recreational activities, and nonpoint source pollution originating in headwater reaches.

Unit FK11: Little River, Russell and Tazewell Counties, Virginia. Unit FK11 includes approximately 50 rkm (31 rmi) of Little River from its confluence with the Clinch River in Russell County, VA, upstream to its confluence with Liberty and Maiden Spring Creeks in Tazewell County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by fluted kidneyshell at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The Nature Conservancy also owns a small portion of adjacent property. The channel within Unit FK11 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitats may require special management considerations or protection to address potential adverse effects associated with silviculturerelated activities, lack of adequate riparian buffers, natural gas and oil exploration activities in headwater reaches, and nonpoint source pollution originating in headwater reaches.

Unit FK12 and SP1: North Fork Holston River, Smyth and Bland Counties, Virginia. Unit FK12 and SP1 includes approximately 67 rkm (42 rmi) of the North Fork Holston River from its confluence with Beaver Creek, upstream of Saltville, in Smyth County, VA, upstream to Ceres, Bland County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings, road easements, and a small portion that is adjacent to the George Washington and Jefferson National Forests. The Nature Conservancy and the Virginia Outdoors Foundation also own a small portion of adjacent property. A portion of this unit (58 rkm (36 rmi)) has been designated as a NEP for the yellowfin madtom (53 FR 29335). The channel within Unit FK12 and SP1 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities, silviculture-related activities, natural gas and oil exploration activities in headwater reaches, lack of adequate riparian buffers, construction and maintenance of State and county roads and nonpoint source pollution originating in headwater reaches.

Unit FK13 and SP2: Middle Fork Holston River, Washington, Smyth, and Wythe Counties, Virginia. Unit FK13 and SP2 includes approximately 89 rkm (55 rmi) of the Middle Fork Holston River from its inundation at South Holston Lake in Washington County, VA, upstream to its headwaters in Wythe County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both the fluted kidneyshell and slabside pearlymussel at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The channel within Unit FK13 and SP2 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities, lack of adequate riparian buffers, silviculture-related activities, and nonpoint source pollution.

Unit FK14 and SP3: Big Moccasin Creek, Scott and Russell Counties, Virginia. Unit FK14 and SP3 includes approximately 33 rkm (21 rmi) of Big Moccasin Creek from the Highway 71 Bridge crossing in Scott County, VA, upstream to the Route 612 Bridge crossing near Collinwood in Russell County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell, but within the species' historical range. Live fluted kidneyshell have not been collected in Big Moccasin Creek since the early 1900s (Ortmann 1918, p. 608). However, this unit is designated as critical habitat for the fluted kidneyshell because it is considered essential for the conservation of the species (see Criteria Used To Identify Critical Habitat above for our rationale). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The channel within Unit FK14 and SP3 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities (livestock), lack of adequate riparian buffers, silviculturerelated activities, natural gas and oil exploration activities in headwater reaches, illegal off-road vehicle use and other recreational activities, and nonpoint source pollution originating in headwater reaches.

Unit FK15: Copper Creek, Scott County, Virginia. Unit FK15 includes 55.5 rkm (34.5 rmi) of Copper Creek from its confluence with the Clinch River upstream to the Highway 71 Bridge crossing in Scott County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell. This unit is included in the geographical area occupied by the species at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. A portion of this unit

(21 rkm (13 rmi)) has been designated as critical habitat for the Cumberlandian combshell, rough rabbitsfoot, purple bean, and oyster mussel, and this unit (55.5 rkm (34.5 rmi)) also makes up a portion of the designated critical habitat for the yellowfin madtom (42 FR 45526, 42 FR 47840, 69 FR 53136). The channel within Unit FK15 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell and its habitat may require special management considerations or protection to address potential adverse effects associated with agricultural activities (livestock), silviculture-related activities, lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK16 and SP4: Clinch River, Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia. Unit FK16 and SP4 includes approximately 263 rkm (163 rmi) of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island in Hancock County, TN, upstream to its confluence with Indian Creek near Cedar Bluff, Tazewell County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. Approximately 6 rkm (4 rmi) of this unit is in public ownership, including portions of the Kyles Ford State Managed Area, George Washington National Forest, Jefferson National Forest, Cleveland Barrens State Natural Area Preserve (SNAP), and the Pinnacle SNAP. The Nature Conservancy also owns a small portion of adjacent property. The unit completely overlaps critical habitat for the Cumberlandian combshell, rough rabbitsfoot, purple bean, and oyster mussel, and the entire length of this unit has been designated as critical habitat for the slender chub and yellowfin madtom (42 FR 45526, 42 FR 47840, 69 FR 53136). The channel within Unit FK16 and SP4 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with coal mining, silviculture-related activities, natural gas and oil exploration activities in headwater reaches, agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK17 and SP5: Powell River, Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia. Unit FK17 and SP5 includes approximately 153 rkm (95 rmi) of the Powell River from the U.S. 25E Bridge in Claiborne County, TN, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs) in Lee County, VA. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings, road easements, and a small portion that is adjacent to the Cedars SNAP. The Nature Conservancy also owns a small portion of adjacent property. The unit completely overlaps critical habitat for the Cumberlandian combshell, rough rabbitsfoot, purple bean, and oyster mussel, and the entire length of this unit has been designated as critical habitat for the slender chub and yellowfin madtom (42 FR 45526, 42 FR 47840, 69 FR 53136). The channel within Unit FK17 and SP5 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with coal mining, natural gas and oil exploration activities in headwater reaches, agricultural activities (livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK18 and SP6: Nolichucky River, Cocke, Hamblen, and Greene Counties, Tennessee. Unit FK18 and SP6 includes approximately 52 rkm (32 rmi) of the Nolichucky River from rkm 14 (rmi 9), approximately 0.6 rkm (0.4 rmi) upstream of Enka Dam, where it divides Hamblen and Cocke Counties, TN, upstream to its confluence with Pigeon Creek, just upstream of the Highway 321 Bridge crossing, in Greene County, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. The fluted kidneyshell population is a result of a successful reintroduction program implemented by TWRA and other conservation partners. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings, road easements, and a small portion that is within Mullins Island Wildlife Management Area. A portion of this unit (8 rkm (5 rmi)) has been designated as a critical habitat for the oyster mussel and Cumberlandian combshell (69 FR 53136). The channel within Unit FK18 and SP6 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel and the fluted kidneyshell, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities, silviculture-related activities, rock mining, lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK19: Holston River, Knox, Grainger, and Jefferson Counties, Tennessee. Unit FK19 includes approximately 85 rkm (53 rmi) of the Holston River from its confluence with the French Broad River in Knox County, TN, upstream to the base of Cherokee Dam at rkm 83.7 (rmi 52.3) along the Grainger and Jefferson County, TN, line. The unit is within the Tennessee River system. This unit is considered unoccupied by the fluted kidneyshell and slabside pearlymussel, but within the species' historical ranges. Live fluted kidneyshell have not been collected in the Holston River since the early 1900s (Ortmann 1918, p. 614). As discussed below, we consider Unit FK19 essential for the conservation of the fluted kidneyshell, but not the slabside pearlymussel, and so it is designated as critical habitat only for the fluted kidneyshell. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The unit completely overlaps a designated nonessential experimental population for 15 mussels, 1 snail, and 5 fishes (72 FR 52434). We consider this unit essential for the conservation of the fluted kidneyshell due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. Although live fluted kidneyshell have not been collected in the Holston River since the early 1900s (Ortmann 1918, p. 614), the Tennessee Valley Authority (TVA) has improved conditions for aquatic species within this unit. Between 1988 and 1995, TVA implemented reservoir release improvements below Cherokee Dam on the Holston River. These improvements included the establishment of minimum flows and increasing the amount of dissolved oxygen in the tailwater below the reservoir (Scott et al. 1996, p. 21). The unit currently supports populations of three federally listed species (threatened snail darter and endangered pink mucket and sheepnose). In addition, other mussel species co-occur with these species along with a diverse fish fauna, including hosts for the fluted kidneyshell. These host fishes are bottom-dwelling species that are able to move into refugia of low flows during high discharges from the hydropower dam upstream. Therefore, the fluted kidneyshell glochidia may come into contact and infest the host fishes. The slabside pearlymussel and its host fishes are known from the Holston River drainage; however, hydropower operations make this habitat unsuitable for mid-water column fishes, such as the shiners that are hosts for the slabside pearlymussel (Layzer and Scott 2006, pp. 481, 488–9). Therefore, we are not designating Unit FK19 as critical habitat for the slabside pearlymussel at this time.

Unit FK20: French Broad River, Knox and Sevier Counties, Tennessee. Unit FK20 includes approximately 56 rkm (35 rmi) of the French Broad River from its confluence with the Holston River in Knox County, TN, upstream to the base of Douglas Dam at rkm 51.7 (rmi 32.3) in Sevier County, TN. The unit is within the Tennessee River system. This unit is considered unoccupied by the fluted kidneyshell and slabside pearlymussel, but within the species' historical ranges. Fluted kidneyshell are only known from archaeological records in the French Broad River (Parmalee 1988 in Layzer and Scott 2006, pp. 481–482). As discussed below, we consider Unit FK20 essential for the conservation of the fluted kidneyshell, but not the slabside pearlymussel, and so it is designated as critical habitat only for the fluted kidneyshell. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements and a small portion that is within Forks of the River Wildlife Management Area. The unit completely overlaps a NEP for 15 mussels, 1 snail, and 5 fishes (72 FR 52434). We consider this unit essential for the conservation of the fluted kidneyshell due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. Fluted kidneyshell are only known from archaeological records in the French Broad River (Parmalee 1988 in Layzer and Scott 2006, pp. 481–482). However, between 1987 and 1995, TVA implemented reservoir release improvements below Douglas Dam on the French Broad River. These improvements included the establishment of minimum flows and increasing the amount of dissolved oxygen in the tailwater below the reservoir (Scott et al. 1996, pp. 11–12), improving conditions for the fluted kidneyshell and other aquatic species. The unit does currently support populations of the federally threatened snail darter and endangered pink mucket. In addition, other mussel species co-occur with these species and a diverse fish fauna, including hosts for the fluted kidneyshell. These host fishes are bottom-dwelling species that are able to move into refugia of low flows during high discharges from the hydropower dam upstream. Therefore, the fluted kidneyshell glochidia may come into contact and infest the host fishes. The slabside pearlymussel and its host fishes are known from the French Broad River drainage; however, hydropower operations make this habitat unsuitable for mid-water column fishes, such as the shiners that are hosts for the slabside pearlymussel (Layzer and Scott 2006, pp. 481, 488–9). Therefore, we are not designating Unit FK20 as critical habitat for the slabside pearlymussel at this time.

Unit FK21 and SP7: Hiwassee River, Polk County, Tennessee. Unit FK21 and SP7 includes approximately 24 rkm (15 rmi) of the Hiwassee River from the Highway 315 Bridge crossing upstream to the Highway 68 Bridge crossing in Polk County, TN. The unit is within the Tennessee

River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell at the time of listing, but within the species' historical range. Fluted kidneyshell are only known from archaeological records in the Hiwassee River (Parmalee and Bogan 1998, p. 205). This unit is considered essential for the conservation of the fluted kidneyshell (see Criteria Used To Identify Critical Habitat above for our rationale). A portion of this unit is considered a ''cut-off'' reach, because most of the water flow bypasses the reach through a tunnel from Apalachia Dam to the Apalachia powerhouse for the production of electricity. This unit is located entirely on federal lands within the Cherokee National Forest (CNF). Land and resource management decisions and activities within the CNF are guided by CNF's LRMP (USFS 2004b, pp. 28–37, entire). The channel within Unit FK21 and SP7 has an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2). Diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with silviculture-related activities, nonpoint source pollution, water diversion through Apalachia tunnel, and potential canopy loss caused by infestations of the hemlock woolly adelgid. Another threat to the species and their habitat which may require special management of the PCEs is the potential for significant changes in the existing flow regime and water quality due to upstream impoundment. As discussed in the final listing rule published elsewhere in today's Federal Register under Summary of Factors Affecting the Species, ''Impoundments,'' mollusk declines below dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles below the dam.

Unit FK22 and SP10: Elk River, Limestone County, Alabama, and Giles, Lincoln, Franklin, and Moore Counties, Tennessee. Unit FK22 and SP10 includes approximately 164 rkm (102 rmi) of the Elk River from its inundation at Wheeler Lake in Limestone County, AL, upstream to its confluence with Farris Creek at the dividing line between Franklin and Moore Counties, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell, but within the species' historical range. Live fluted kidneyshell have not been collected in the Elk River since the late- 1960s (Isom et al. 1973, p. 440). The unit is considered essential for the conservation of the fluted kidneyshell (see Criteria Used To Identify Critical Habitat above for our rationale). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements and a small portion that is within TVA-owned lands near Wheeler Reservoir. Unit FK22 and SP10 has an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with hydropower generation from Tims Ford Dam, agriculture, nonpoint source pollution, and instream gravel mining. Another threat to the species and their habitat which may require special management of the PBFs is the potential for significant changes in the existing flow regime and water quality due to upstream impoundment. As discussed in the final listing rule published elsewhere in today's Federal Register under Summary of Factors Affecting the Species, ''Impoundments,'' mollusk declines below dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles below the dam.

Unit FK23 and SP12: Duck River, Humphreys, Perry, Hickman, Maury, Marshall, and Bedford Counties, Tennessee. Unit FK23 and SP12 includes approximately 348 rkm (216 rmi) of the Duck River from its inundation at Kentucky Lake in Humphreys County, TN, upstream to its confluence with Flat Creek near Shelbyville in Bedford County, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by both species at the time of listing. The fluted kidneyshell population is a result of a successful reintroduction program implemented by TWRA and other conservation partners, resulting in the recruitment of the species in the Duck River. Approximately 64 rkm (39 rmi) of this unit is federally or State-owned and adjacent to the Tennessee National Wildlife Refuge, Natchez Trace Parkway, Yanahli Wildlife Management Area, and Henry Horton State Park; the remainder is privately owned. A portion of this unit (74 rkm (46 rmi)) has been designated as a critical habitat for the oyster mussel and Cumberlandian combshell (69 FR 53136) and a portion of this unit (235 rkm (146 rmi)) is critical habitat for the rabbitsfoot (78 FR 57076). The channel within Unit FK23 and SP12 is relatively stable, with suitable instream habitat (PCE 1). There is an abundance of riffle habitats (PCE 1), with relatively silt-free sand and gravel substrates (PCE 2), and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the fluted kidneyshell and slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the fluted kidneyshell, slabside pearlymussel, and their habitats may require special management considerations or protection to address potential adverse effects associated with agricultural activities (livestock), water withdrawals, lack of adequate riparian buffers, construction and maintenance of State and county roads, and nonpoint source pollution originating in headwater reaches.

Unit FK24 and SP13: Buffalo River, Humphreys and Perry Counties, Tennessee. Unit FK24 and SP13 includes approximately 50 rkm (31 rmi) of the Buffalo River from its confluence with the Duck River in Humphreys County, TN, upstream to its confluence with Cane Creek in Perry County, TN. The unit is within the Tennessee River system and is critical habitat for the fluted kidneyshell and slabside pearlymussel. This unit is included in the geographical area occupied by slabside pearlymussel at the time of listing. This unit is considered unoccupied by the fluted kidneyshell, but within the species' historical range. Live fluted kidneyshell have not been collected in the Buffalo River since the early 1920s (Ortmann 1924, p. 28). The unit is considered essential for the conservation of the fluted kidneyshell (see Criteria Used To Identify Critical Habitat above for our rationale). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Unit FK24 and SP13 has an abundance of riffle habitats (PCE 1) and adequate instream flows (PCE 3). A diverse fish fauna, including fish hosts for the slabside pearlymussel, are known from this unit (PCE 5). Within this unit, the slabside pearlymussel and its habitats may require special management considerations or protection to address potential adverse effects associated with agriculture, destabilized substrates, and nonpoint source pollution.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Limestone County, Alabama; Jackson, Laurel, McCreary, Pulaski, Rockcastle, and Wayne Counties, Kentucky; Bedford, Claiborne, Cocke, Fentress, Franklin, Giles, Grainger, Greene, Hamblen, Hancock, Hickman, Humphreys, Jefferson, Knox, Lincoln, Marshall, Maury, Moore, Morgan, Overton, Perry, Pickett, Polk, Scott, and Sevier Counties, Tennessee; and Bland, Lee, Russell, Scott, Smyth, Tazewell, Washington, and Wythe Counties, Virginia. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of fluted kidneyshell consist of five components:

(i) Riffle habitats within large, geomorphically stable stream channels (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand, gravel, and cobble with low to moderate amounts of fine sediment and containing flow refugia with low shear stress.

(iii) A natural hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species is found, and connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability for all life stages, and spawning habitat for native fishes.

(iv) Water quality with low levels of pollutants and including a natural temperature regime, pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams/liter), hardness, and turbidity necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of abundant fish hosts, which may include the barcheek darter, fantail darter, rainbow darter, redline darter, bluebreast darter, dusky darter and banded sculpin, necessary for recruitment of the fluted kidneyshell.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on October 28, 2013.

Various activities in or adjacent to each of the occupied critical habitat units described in this final rule may affect one or more of the PBFs. Special management considerations or protection will conserve the PBFs for these species. Management activities that could ameliorate threats on both Federal and non-Federal lands include, but are not limited to: Use of best management practices (BMPs) designed to reduce sedimentation, erosion, and stream bank alteration; moderation of surface and ground water withdrawals to maintain natural flow regimes; increase of stormwater management and reduction of stormwater flows into the systems; preservation of headwater streams; regulation of off-road vehicle use; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water.

Life History

Feeding Narrative

Adult: Adults are detritivores, while larvae are parasitic. Adult phenology is diurnal (NatureServe, 2015). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column. Adult mussels also can obtain their food by deposit feeding, pulling in food from the sediment and its interstitial (pore) water, and pedal- (foot-) feeding directly from the sediment (Yeager et al. 1994, pp. 217– 221;

Vaughn and Hakenkamp 2001, pp. 1432–1438; Nichols et al. 2005, pp. 90– 93). Juveniles typically burrow completely beneath the substrate surface and are deposit or pedal feeders. Food items include detritus (disintegrated organic debris), algae, diatoms, and bacteria (Strayer et al. 2004, pp. 430–431) (USFWS, 2013).

Reproduction Narrative

Adult: This species is unusual in that outer portion of a brooding female's outer gills folded in a curtain-like fashion (characteristic of the genus). It is thought to have a late summer or early fall fertilization period with glochidia incubating overwinter. Glochidia are released the following spring or early summer as conglutinates. Conglutinates are shaped like insect larvae, and have an adhesive end that sticks to silt-free stones on the stream bottom. Host fishes include: Etheostoma obeyense (barcheek darter), Etheostoma rufilineatum (redline darter), Etheostoma flabellare (fantail darter), Etheostoma caeruleum (redline darter), Cottus carolinae (banded sculpin) (Luo and Layzer, 1993) (NatureServe, 2015). Reported longevity of the fluted kidneyshell ranges from 26 to 55 years (Henley et al. 2002, p. 19; Davis and Layzer 2012, p. 92). Females can become sexually mature at age 5 (Davis and Layzer 2012, p. 79) (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits small to medium rivers in areas with swift current or riffles, although a few populations were recorded from larger rivers in shoal areas. It is often found embedded in sand, gravel, and cobble substrates (Gordon and Layzer, 1989). This species is highly vulnerable and has a narrow environmental specificity. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Number of Populations:

10 Extant (USFWS, 2021)

Population Size:

>10,000 (USFWS, 2021)

Population Narrative:

Currently ten of the twenty historical Fluted Kidneyshell populations are extant, with three and seven populations occupying the Cumberland and Tennessee River drainages, respectively (Figure E1). Several of the extirpated populations are the result of impoundments (i.e., Holston), while the causes of the other extirpations are not clear. (USFWS, 2021)

Threats and Stressors

Stressor: Impoundments (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Impoundments result in the dramatic modification of riffle and shoal habitats and the resulting loss of mussel resources, especially in larger rivers. Dams interrupt most of a river's ecological processes by modifying flood pulses; controlling impounded water elevations; altering water flow, sediments, nutrients, energy inputs, and outputs; increasing depth; decreasing habitat heterogeneity; and decreasing bottom stability due to subsequent sedimentation. In addition, dams can also seriously alter downstream water quality and riverine habitat and negatively impact tailwater mussel populations. These changes include thermal alterations immediately below dams; changes in channel characteristics, habitat availability, and flow regime; daily discharge fluctuations; increased silt loads; and altered host fish communities. Given projected human population increases and the need for municipal water supply, other

proposals for small impoundment construction are likely in the future within the Cumberland and Tennessee River systems (USFWS, 2013).

Stressor: Mining and commercial navigation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Negative impacts associated with gravel mining include stream channel modifications (e.g., altered habitat, disrupted flow patterns, sediment transport), water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature), macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation), and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions) (Kanehl and Lyons 1992, pp. 26–27). Channel modification for commercial navigation has been shown to increase flood heights (Belt 1975, p. 684), partly as a result of an increase in stream bed slope (Hubbard et al. 1993, p. 137). Flood events are exacerbated, conveying large quantities of sediment, potentially with adsorbed contaminants, into streams. Channel maintenance often results in increased turbidity and sedimentation that often smothers mussels (Stansbery 1970, p. 10). Heavy metal-rich drainage from coal mining and associated sedimentation has adversely impacted historically diverse mussel faunas in the upper Cumberland and Tennessee River system streams. Strip mining continues to threaten mussel habitats in coal field drainages of the Cumberland Plateau, including streams harboring small fluted kidneyshell populations (e.g., Horse Lick Creek, Little South Fork, Powell River, Indian Creek). The habitats of fluted kidneyshell, slabside pearlymussel, and other mussels in the Clinch and Powell Rivers are increasingly being threatened by coal mining activities. Price (2011, p. VIII–3) indicates total dissolved solids concentrations have continued to rise in the Powell and Clinch Rivers, with rapid increases in the upper Powell River, where coal mining is most prominent (USFWS, 2013).

Stressor: Oil and natural gas development (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Exploration and extraction of these energy resources has the potential to result in increased siltation, a changed hydrograph (flow regime), and altered water quantity and quality even at a distance from the mine or well field. Although oil and natural gas extraction generally occurs away from the river, extensive road and pipeline networks are required to construct and maintain wells and transport the extracted resources. These road and pipeline networks frequently cross or occur near tributaries, contributing sediment to the receiving waterway. In addition, the construction and operation of wells may result in the illegal discharge of chemical contaminants and subsurface minerals (USFWS, 2013).

Stressor: Sedimentation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Sources of silt and sediment include poorly designed and executed timber harvesting operations and associated activities; complete clearing of riparian vegetation for agricultural, silvicultural, or other purposes; and those construction, mining, and other practices that allow exposed earth to enter streams. Agricultural activities, specifically an increase in cattle grazing

and the resultant nutrient enrichment and loss of riparian vegetation along the stream, are responsible for much of the sediment (Fraley and Ahlstedt 2000, p. 193; Hanlon et al. 2009, pp. 11–12). Heavy sediment loads can destroy mussel habitat, resulting in a corresponding shift in mussel fauna (Brim Box and Mossa 1999, p. 100). Excessive sedimentation can lead to rapid changes in stream channel position, channel shape, and bed elevation (Brim Box and Mossa 1999, p. 102). Sedimentation has also been shown to impair the filter feeding ability of mussels, and high amounts of suspended sediments can dilute their food source (Dennis 1984, p. 212) (USFWS, 2013).

Stressor: Chemical contaminants (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Chemicals enter the environment through both point and nonpoint discharges, including spills, stormwater infrastructure, industrial sources, municipal effluents, and agricultural runoff. These sources contribute organic compounds, heavy metals, pesticides, and a wide variety of newly emerging contaminants to the aquatic environment. As a result, water and sediment quality can be degraded to the extent that mussel habitats and populations are adversely impacted (USFWS, 2013).

Stressor: Population fragmentation and isolation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Population isolation prohibits the natural interchange of genetic material between populations, and small population size reduces the reservoir of genetic diversity within populations, which can lead to inbreeding depression (Allendorf and Luikart 2007, pp. 117– 146). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153). It is likely that some populations of the fluted kidneyshell are below the effective population size (Soule´ 1980, pp. 162–164; Allendorf and Luikart 2007, pp. 147–170) required to maintain long-term genetic and population viability (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin et al. 2002, p. 6074; Cook et al. 2004, p. 1015; Golladay et al. 2004, p. 504). Specific effects of climate change to mussels, their habitats, and their fish hosts could include changes in stream temperature regimes and changes in the timing and levels of precipitation, causing more frequent and severe floods and droughts. Increases in temperature and reductions in flow can also lower dissolved oxygen levels in interstitial habitats, which can be lethal to juveniles (Sparks and Strayer 1998, pp. 131–133). Even small increases in temperature can cause reductions in the survival of freshwater mussel glochidia and juveniles, and temperatures currently encountered in the temperate United States during summers are close to or above the upper thermal tolerances of early life stages of freshwater mussels (Pandolfo et al. 2010, pp. 965, 967). Effects to mussel populations from these environmental

changes could include reduced abundance and biomass, altered species composition, and reduced host fish availability (Galbraith et al. 2010, pp. 1180–1182) (USFWS, 2013).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 2

Delisting Criteria:
Criterion 1 At least 12 populations demonstrate a stable or increasing trend, natural recruitment, and multiple age classes over a 15-year period. At least 3 of these populations occur in each of the following drainages: Cumberland River, lower Tennessee River, and upper Tennessee River. An additional 3 populations are necessary for species redundancy, but these populations can be distributed among any of the 3 historic drainage basins (Cumberland River, Upper Tennessee River, and Lower Tennessee River). Criterion 2 Threats have been addressed and/or managed to the extent that water quality, instream habitat, and connectivity between and among populations will be maintained at levels meeting life history requirements of the species. Additionally, pathogen prevalence and disease incidence should occur at sufficiently low levels such that effects on population growth and demography are insignificant. (USFWS, 2022)

Recovery Actions:

- 1. Increase knowledge of the biology of the species, particularly its response to threats. 2. Conduct research on species' population genetics. 3. Consistently monitor the status of existing populations. 4. Utilize existing regulations, voluntary conservation practices, removal of barriers, and land acquisition to protect extant populations by reducing threats and maintaining, enhancing, and restoring habitat in their watersheds.. 5. Continue propagation and augment populations, as appropriate. 6. Reduce threats in currently unoccupied watersheds within the range of the species. 7. Reintroduce new populations to unoccupied habitat within the historical range of the species. 8. Search for undocumented populations and undocumented occupied reaches within the range of the species. 9. Conduct outreach to local communities in the range of the species to gain support of conservation efforts and foster stewardship of watersheds. 10.Conduct periodic review of recovery progress and strategy. (USFWS, 2022)

Conservation Measures and Best Management Practices:

- Fluted Kidneyshell populations are susceptible to numerous natural and anthropogenic stressors and threats that occur within their watersheds. As discussed in the previous chapter, to remain resilient, Fluted Kidneyshell populations need suitable and stable water quality and habitat quality, as well as good connectivity within and among populations to allow for gene flow. Stressors and threats can influence one or more of these needs, and the degree to which they influence the habitat factors can vary across the range of the species. Habitat factors influence the demographic factors of a population, such as growth and recruitment. Demographic factors in healthy populations can offset and mitigate some effects of threats, but the current and potential extent and magnitude of the threats influence viability. Conservation measures (e.g., riparian buffers, propagation) and regulatory management can mitigate negative effects to increase the resiliency of a population, or the redundancy and representation of the species across its range, thus increasing viability. (USFWS, 2021)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Fluted Kidneyshell and Slabside Pearlymussel. Final rule. 78 FR 59555 - 59620 (September 26, 2013).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2013. Endangered and Threatened Wildlife and Plants

Endangered Species Status for the Fluted Kidneyshell and Slabside Pearlymussel. 78 Federal Register 187. September 26, 2013. Pages 59269 - 59287.

Endangered Species Status for the Fluted Kidneyshell and Slabside Pearlymussel. 78 Federal Register 187. September 26, 2013. Pages 59269 - 59287. USFWS. 2021. Species Status Assessment Report for the Fluted Kidneyshell (Ptychobranchus subtentum (=subtentus)), Version 1.0. February 2021. Atlanta, GA.

USFWS. 2013. Endangered and Threatened Wildlife and Plants

USFWS. 2022. Recovery plan for the Fluted Kidneyshell (Ptychobranchus subtentus). Atlanta, Georgia. 9 pp.

USFWS. 2021. Species Status Assessment Report for the Fluted Kidneyshell (Ptychobranchus subtentum (=subtentus)), Version 1.0. February 2021. Atlanta, GA.

SPECIES ACCOUNT: *Quadrula cylindrica cylindrica* (Rabbitsfoot)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/17/2013; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A highly distinctive mussel with an elongate shell, rectangular in shape with pustules and chevron markings. Oesch (1984, p 91) gives the following description of the animal. "Branchial opening moderately large with brownish-yellow tentacles; anal finely papillose; supra-anal briefly connected to anal by mantle edge; gills very long and narrow, outer more narrow anteriorly; inner laminae free from visceral mass; palpi long, narrow; connected one-third of their length antero-dorsad; color of soft parts peculiar, foot with orange background striped in black; visceral mass uniorange, mantles with black pigment especially along the margins at siphonal openings." (NatureServe, 2015)

Taxonomy

See Stansbery (1970) to differentiate from Quadrula cylindrica strigillata. Has also been placed in the genera Unio and Orthonymus. Two subspecies are currently recognized; Quadrula cylindrica cylindrica (Say, 1817) of the upper Ohio River drainage and Quadrula cylindrica strigillata (B.H. Wright, 1898) in the Tennessee River drainage (Butler, 2005) with morphological differentiation provided in Stansbery (1970). Recent examination of mitochondrial DNA sequences of 888 base-pairs from 32 Q. cylindrica cylindrica from Tennessee, Arkansas, and Kentucky, and 7 Q. cylindrica strigillata from Tennessee indicate these two subspecies do not represent taxonomic entities (FMCS annual meeting abstracts, 2007). (NatureServe, 2015)

Historical Range

Historically, the rabbitsfoot occurred in the lower Great Lakes sub-basin and Mississippi River Basin from 137 streams in 15 states including: the lower Great Lakes sub-basin, Ohio River system, Cumberland River system, Tennessee River system, lower Mississippi River sub-basin, White River system, Arkansas River system, Red River system. Reports from Nebraska, Michigan, Iowa, and New York, are questionable, at best (Butler, 2005). (NatureServe, 2015)

Current Range

It is found throughout the Ohio River drainage from headwaters in Pennsylvania to the mouth of the Ohio River (Ortmann, 1919; Cummings and Mayer, 1992). It is widespread in the Cumberland River drainage downstream of Cumberland Falls (Cicerello et al., 1991; Parmalee and Bogan, 1998) and in the Tennessee River drainage from headwaters in southwestern Virginia downstream to the mouth of the Tennessee River (Ahlstedt, 1992a; 1992b; Parmalee and Bogan, 1998). It also occurs in some tributaries of the lower Mississippi River from southeastern Kansas (Murray and Leonard, 1962) and Missouri (Oesch, 1995) south to Arkansas (Harris and Gordon, 1990), northern Louisiana (Vidrine, 1993) and Mississippi (Jones et al., 2005). The rabbitsfoot is believed extirpated from Georgia and West Virginia, while its continued existence in several other states (e.g., Alabama, Kansas, Louisiana, Mississippi, Missouri) is extremely perilous (Butler, 2005). (NatureServe, 2015)

Critical Habitat Designated

Yes; 4/30/2015.

Legal Description
On April 30, 2015, the U.S. Fish and Wildlife Service (Service), designated critical habitat for the rabbitsfoot (Quadrula cylindrica cylindrica), under the Endangered Species Act of 1973, as amended (Act). In total, approximately 2,312 river kilometers (1,437 river miles) in Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Mississippi, Missouri, Ohio, Oklahoma, Pennsylvania, and Tennessee, fall within the boundaries of the critical habitat designation for the rabbitsfoot.
The Service finds the areas designated as critical habitat were occupied at the time of listing and contain the features essential to the conservation of the rabbitsfoot, and these features may require special management considerations or protection.

Critical Habitat Designation

The critical habitat designation for Quadrula cylindrica cylindrica includes 31 units totaling approximately 2,312 rkm (1,437 rmi) in Colbert, Jackson, Madison, and Marshall Counties, Alabama; Arkansas, Ashley, Bradley, Clark, Cleburne, Cleveland, Drew, Hot Spring, Independence, Izard, Jackson, Lawrence, Little River, Marion, Monroe, Newton, Ouachita, Randolph, Searcy, Sevier, Sharp, Van Buren, White, and Woodruff Counties, Arkansas; Massac, Pulaski, and Vermilion Counties, Illinois; Carroll, Pulaski, Tippecanoe, and White Counties, Indiana; Allen and Cherokee Counties, Kansas; Ballard, Edmonson, Green, Hart, Livingston, Logan, Marshall, McCracken, and Taylor Counties, Kentucky; Hinds, Sunflower, Tishomingo, and Warren Counties, Mississippi; Jasper, Madison, and Wayne Counties, Missouri; Coshocton, Madison, Union, and Williams Counties, Ohio; McCurtain and Rogers Counties, Oklahoma; Crawford, Erie, Mercer, and Venango Counties, Pennsylvania; and Hardin, Hickman, Humphreys, Marshall, Maury, Montgomery, Perry, and Robertson Counties, Tennessee.

Unit RF1: Spring River—Jasper County, Missouri; and Cherokee County, Kansas. Unit RF1 includes 56.5 rkm (35.1 rmi) of the Spring River from Missouri Highway 96 at Carthage, Jasper County, Missouri, downstream to the confluence of Turkey Creek north of Empire, Cherokee County, Kansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection described above. The majority of the riparian lands adjacent to, but not included in, this unit are in private ownership or private lands under tribal jurisdiction.

Unit RF2: Verdigris River—Rogers County, Oklahoma. Unit RF2 includes 38.0 rkm (23.6 rmi) of the Verdigris River from Oologah Lake dam north of Claremore, Oklahoma, downstream to Oklahoma Highway 266 northwest of Catoosa, Rogers County, Oklahoma. This unit contains all or some components of all four physical or biological features and in part, contains primary constituent elements 3, 4, and 5. It is possible that primary constituent elements 1 and 2 are limiting factors for rabbitsfoot distribution and abundance from Oologah Lake dam downstream to the confluence of the Caney River; thus we are unable to determine at this time whether this reach contains primary constituent elements 1 and 2. The physical or biological features in this unit may require special management considerations or protection as described above and changes in the existing flow regime due to such activities as impoundment, tail water releases from Oologah Lake dam, and channelization associated with the McClellan-Kerr Arkansas River Navigation System. The majority of the riparian lands adjacent to, but not included in, this unit are in private ownership or private lands under tribal jurisdiction.

Unit RF3: Neosho River—Allen County, Kansas. Unit RF3 includes 26.6 rkm (16.5 rmi) of the Neosho River from the Deer Creek confluence northwest of Iola, Kansas, downstream to the confluence of Owl Creek southwest of Humboldt, Allen County, Kansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above except for releases of chemical contaminants from industrial and municipal effluents. Approximately 97 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and the remaining lands in State or local ownership.

Unit RF4a: Ouachita River—Clark and Hot Spring Counties, Arkansas. Unit RF4a includes 22.7 rkm (14.1 rmi) of the Ouachita River from the Tenmile Creek confluence north of Donaldson downstream to the Caddo River confluence near Caddo Valley, Hot Spring and Clark Counties, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. Approximately 82 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and the remaining 18 percent are in Federal ownership.

Unit RF4b: Ouachita River—Ouachita County, Arkansas. Unit RF4b includes 43.0 rkm (26.7 rmi) of the Ouachita River from the Little Missouri River confluence downstream to U.S. Highway 79 at Camden, Ouachita County, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. All the riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF5: Saline River—Ashley, Bradley, Cleveland, and Drew Counties, Arkansas. Unit RF5 includes 119.4 rkm (74.2 rmi) of the Saline River from Frazier Creek confluence near Mount Elba, Cleveland County, Arkansas, to the Mill Creek confluence near Stillions, Ashley and Bradley Counties, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. All the riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF6: Little River—McCurtain County, Oklahoma; and Little River and Sevier Counties, Arkansas. Unit RF6 includes 139.7 rkm (86.8 rmi) of the Little River from the Glover River confluence northwest of Idabel, McCurtain County, Oklahoma, downstream to U.S. Highway 71 north of Wilton, Little River and Sevier Counties, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. Riparian lands adjacent to, but not included in, this unit are in private ownership (42 percent), Federal (35 percent), and private land under tribal jurisdiction (23 percent).

Unit RF7: Middle Fork Little Red River—Cleburne and Van Buren Counties, Arkansas. Unit RF7 includes 24.8 rkm (15.4 rmi) of the Middle Fork Little Red River from the confluence of Little Tick Creek north of Shirley, Arkansas, downstream to Greers Ferry Reservoir (where inundation begins), Van Buren County, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above and natural gas development and hillside rock harvesting. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF8a: White River—Independence, Jackson, White, and Woodruff Counties, Arkansas. Unit RF8a includes 188.3 rkm (117.0 rmi) of the White River from the Batesville Dam at Batesville, Independence County, Arkansas, downstream to the Little Red River confluence north of Georgetown, White, and Woodruff Counties, Arkansas. This unit contains all or some components of all four physical or biological features and contains primary constituent elements 2, 3, 4, and 5. The ACOE maintains a navigation channel, which involves routine dredging and snag removal, from Newport, Arkansas, to its confluence with the Mississippi River. The physical or biological features in this unit may require special management considerations or protection described above except for releases of chemical contaminants from industrial and municipal effluents and including tail water releases from a series of reservoirs on the upper White River; row crop agriculture; increasing demand for instream sand from the White River upstream of Newport, Arkansas, to support natural gas development needs; natural gas development; and channelization. Riparian lands adjacent to, but not included in, this unit are in private ownership (94 percent) and State and local ownership (6 percent). Unit RF8b: White River—Arkansas and Monroe Counties, Arkansas. There are no records of rabbitsfoot from the 160-rkm (100-rmi) reach separating Unit RF8a from Unit RF8b (Butler 2005, p. 66). Unit RF8b includes 68.9 rkm (42.8 rmi) of the White River from U.S. Highway 79 at Clarendon, Monroe County, Arkansas, downstream to Arkansas Highway 1 near St. Charles, Arkansas County, Arkansas. This unit contains all or some components of all four physical or biological features and contains primary constituent elements 2, 3, 4, and 5. The ACOE maintains a navigation channel, which involves routine dredging and snag removal, from Newport, Arkansas, to its confluence with the Mississippi River. The physical or biological features in this unit may require special management considerations or protection described above except for releases of chemical contaminants from industrial and municipal effluents and including tail water releases from a series of reservoirs on the upper White River; row crop agriculture; increasing demand for instream sand from the White River upstream of Newport, Arkansas, to support natural gas development needs; natural gas development; and channelization. Approximately 84 percent of the riparian lands adjacent to, but not included in, this unit are in Federal ownership and 16 percent are in private ownership.

Unit RF9: Black River—Lawrence and Randolph Counties, Arkansas. Unit RF9 includes 51.2 rkm (31.8 rmi) of the Black River from U.S. Highway 67 at Pocahontas, Randolph County, Arkansas, downstream to the Flat Creek confluence southeast of Powhatan, Lawrence County, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above and including row crop agriculture. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF10: Spring River—Lawrence, Randolph, and Sharp Counties, Arkansas. Unit RF10 includes 51.5 rkm (32.0 rmi) of the Spring River from the Ott Creek confluence southwest of Hardy in Sharp County, Arkansas, downstream to its confluence with the Black River east of Black Rock, Lawrence and Randolph Counties, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF11: Strawberry River— Independence, Izard, Lawrence, and Sharp Counties, Arkansas. Unit RF11 includes 123.8 rkm (76.9 rmi) of the Strawberry River from Arkansas Highway 56 south of Horseshoe Bend, Izard County, Arkansas, downstream to its confluence with the Black River southeast of Strawberry, Lawrence County, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF12: Buffalo River—Marion, Newton, and Searcy Counties, Arkansas. Unit RF12 includes 113.6 rkm (70.6 rmi) of the Buffalo River from the Cove Creek confluence southeast of Erbie, Newton County, Arkansas, downstream to U.S. Highway 65 west of Gilbert, Searcy County, Arkansas and Arkansas Highway 14 southeast of Mull, Arkansas, downstream to the Leatherwood Creek confluence in the Lower Buffalo Wilderness Area, Arkansas. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. All riparian lands adjacent to, but not included in, this unit are in Federal ownership.

Unit RF13: St. Francis River—Madison and Wayne Counties, Missouri. Unit RF13 includes 64.3 rkm (40.0 rmi) of the St. Francis River from the Twelvemile Creek confluence west of Saco, Madison County, Missouri, downstream to Lake Wappepello (where inundation begins), Wayne County, Missouri. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. Riparian lands adjacent to, but not included in, this unit are in private (59 percent), Federal (39 percent), and less than 2 percent in State or local ownership.

Unit RF14: Big Sunflower River— Sunflower County, Mississippi. Unit RF14 includes 51.5 rkm (32.0 rmi) of the Big Sunflower River from Mississippi Highway 442 west of Doddsville, Mississippi, downstream to the Quiver River confluence east of Indianola, Sunflower County, Mississippi. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above and row crop agriculture and channelization. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF15: Bear Creek—Tishomingo County, Mississippi; and Colbert County, Alabama. Unit RF15 includes 49.7 rkm (30.9 rmi) of Bear Creek from the Alabama and Mississippi State line east of

Golden, Tishomingo County, Mississippi, downstream to Alabama County Road 4 southwest of Sutton Hill, Colbert County, Alabama (just upstream of Pickwick Lake). Unit RF15 in its entirety is currently designated as critical habitat for the oyster mussel (Duck River dartersnapper) and Cumberlandian combshell. Unit RF15 contains all or some components of all four physical or biological features, except in the Bear Creek Floodway, which has been channelized for flood control and only contains components of physical or biological features associated with the species' nutritional or physiological requirements and contains all five primary constituent elements, except in the Bear Creek Floodway, which has been channelized for flood control and only contains primary constituent elements 3, 4, and 5. The physical or biological features in this unit may require special management considerations or protection to address changes described above. Riparian lands adjacent to, but not included in, this unit are in private (64 percent), Federal (24 percent), and 12 percent in State or local ownership.

Unit RF16: Big Black River—Hinds and Warren Counties, Mississippi. Unit RF16 includes 43.3 rkm (26.9 rmi) of Big Black River from Porter Creek confluence west of Lynchburg, Hinds County, Mississippi, downstream to Mississippi Highway 27 west of Newman, Warren County, Mississippi. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above, as well as row crop agriculture and channelization. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF17: Paint Rock River—Jackson, Madison, and Marshall Counties, Alabama. Unit RF17 includes 81.0 rkm (50.3 rmi) of the Paint Rock River from the convergence of Estill Fork and Hurricane Creek north of Skyline, Jackson County, Alabama, downstream to U.S. Highway 431 south of New Hope, Madison and Marshall Counties, Alabama. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above as well as row crop agriculture and channelization. Approximately 99 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 1 percent is in Federal ownership.

Unit RF18: Duck River—Hickman, Humphreys, Marshall, Maury, and Perry Counties, Tennessee. Unit RF18 includes 235.3 rkm (146.2 rmi) of the Duck River from Lillard Mill (rkm 288; rmi 179) west of Tennessee Highway 272, Marshall County, Tennessee, downstream to Interstate 40 near Bucksnort, Hickman County, Tennessee. Seventy-four rkm (46 rmi) in Unit RF18 from rkm 214 (rmi 133) upstream to Lillards Mill at rkm 288 (rmi 179) is currently designated as critical habitat for the oyster mussel and Cumberlandian combshell (50 CFR 17.95(f)). Unit RF18 contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above as well as row crop agriculture and channelization. Approximately 83 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 17 percent are in State or local ownership.

Unit RF19a: Tennessee River—Hardin County, Tennessee. Unit RF19a includes 26.7 rkm (16.6 rmi) of Tennessee River from Pickwick Lake Dam downstream to U.S. Highway 64 near Adamsville, Hardin County, Tennessee. This unit contains all or some components of all four physical or biological features and contains primary constituent elements 1, 3, 4, and 5. The physical or biological features in this unit may require special management considerations or protection to address changes described above as well as row crop agriculture, channelization, and channel stability associated with tail water releases. Approximately 90 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 10 percent are in State or local ownership. Unit RF19b: Tennessee River— Livingston, Marshall, and McCracken Counties, Kentucky. Unit RF19b includes 35.6 rkm (22.1 rmi) of the Tennessee River from Kentucky Lake Dam downstream to its confluence with the Ohio River, McCracken and Livingston Counties, Kentucky. This unit contains all or some components of all four physical or biological features, and in part, contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. Approximately 93 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership, 7 percent are in Federal ownership, and less than 1 percent is in State or local ownership.

Unit RF20: Ohio River—Ballard and McCracken Counties, Kentucky; Massac and Pulaski Counties, Illinois. Unit RF20 includes 45.9 rkm (28.5 rmi) of the Ohio River from the Tennessee River confluence at the downstream extent of Owens Island downstream to Lock and Dam 53 near Olmstead, Illinois. This unit contains all or some components of all four physical or biological features, and in part, contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above, as well as row crop agriculture, channelization, and channel stability associated with tail water releases. Approximately 72 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 28 percent are in State or local ownership.

Unit RF21: Green River—Edmonson, Green, Hart, and Taylor Counties, Kentucky. Unit RF21 includes 175.6 rkm (109.1 rmi) of the Green River from Green River Lake Dam south of Campbellsville, Taylor County, Kentucky, downstream to Mammoth Cave National Park North Entrance Road in Mammoth Cave National Park, Kentucky. This unit contains all or some components of all four physical or biological features, and in part, contains all five primary constituent elements. Releases from Green River Lake dam have altered hydrologic flows and temperature regimes in the tail water reach (Butler 2005, p. 39). The physical or biological features in this unit may require special management considerations or protection to address changes described above and row crop agriculture, channelization, and channel stability associated with tail water releases. Approximately 90 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 10 percent are in Federal ownership.

Unit RF22: French Creek—Crawford, Erie, Mercer, and Venango Counties, Pennsylvania. Unit RF22 includes 120.4 rkm (74.8 rmi) of French Creek from Union City Reservoir Dam northeast of Union City, Erie County, Pennsylvania, downstream to its confluence with the Allegheny River near Franklin, Venango County, Pennsylvania. The Allegheny River rabbitsfoot population (Unit RF23) is likely a single metapopulation with the French Creek population (Unit RF22) (Butler 2005, p. 31). This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above as well as row crop agriculture and oil and gas development. Approximately 97 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 3 percent are in Federal ownership.

Unit RF23: Allegheny River—Venango County, Pennsylvania. Unit RF23 includes 57.3 rkm (35.6 rmi) of the Allegheny River from the French Creek confluence near Franklin, Venango County, Pennsylvania, downstream to Interstate 80 near Emlenton, Venango County, Pennsylvania. The lower Allegheny River and French Creek (Unit RF22) populations likely represent a single metapopulation because no barriers exist between the streams (Butler 2005, p. 29). This unit contains all or some components of all four physical or biological features and likely functions as a metapopulation to French Creek (Unit RF22). This unit contains primary constituent elements 1, 3, 4, and 5 for the rabbitsfoot. A series of nine locks and dams and Kinzua Dam constructed over the past century has resulted in altered hydrologic flow regimes in the Allegheny River (Butler 2005, p. 29). The physical or biological features in this unit may require special management considerations or protection to address changes described above as well as row crop agriculture, oil and gas development, and channelization. Approximately 83 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 17 percent are in State or local ownership.

Unit RF24: Muddy Creek—Crawford County, Pennsylvani. Unit RF24 includes 20.1 rkm (12.5 rmi) of Muddy Creek from Pennsylvania Highway 77 near Little Cooley, Crawford County, Pennsylvania, downstream to its confluence with French Creek east of Cambridge Springs, Crawford County, Pennsylvania. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above and oil and gas development. Approximately 81 percent of the riparian lands adjacent to, but not included in, this unit are in Federal ownership and 19 percent are in private ownership.

Unit RF25: Tippecanoe River—Carroll, Pulaski, Tippecanoe, and White Counties, Indiana. Unit RF25 includes 75.6 rkm (47.0 rmi) of the Tippecanoe River from Indiana Highway 14 near Winamac, Pulaski County, Indiana, downstream to its confluence with the Wabash River northeast of Battle Ground, Tippecanoe County, Indiana, excluding Lakes Shafer and Freeman and the stream reach between the two lakes. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. Approximately 97 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 3 percent are in State or local ownership.

Unit RF26: Walhonding River— Coshocton County, Ohio. Unit RF26 includes 17.5 rkm (10.9 rmi) of the Walhonding River from the convergence of the Kokosing and Mohican Rivers downstream to Ohio Highway 60 near Warsaw, Coshocton County, Ohio. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above. Approximately 83 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 17 percent are in State or local ownership.

Unit RF27: Little Darby Creek—Madison and Union Counties, Ohio. Unit RF27 includes 33.3 rkm (20.7 rmi) of Little Darby Creek from Ohio Highway 161 near Chuckery, Union County, Ohio, downstream to U.S. Highway 40 near West Jefferson, Madison County, Ohio. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above and row crop agriculture. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF28: North Fork Vermilion River and Middle Branch North Fork Vermilion River, respectively, Vermilion County, Illinois. Unit RF28 includes a total of 28.5 rkm (17.7 rmi). Unit RF28 includes 21.2 rkm (13.2 rmi) of the North Fork Vermilion River from the confluence of Middle Branch North Fork Vermilion River downstream to Illinois Highway 1 and U.S. Highway 136 upstream of Lake Vermilion, Vermilion County, Illinois. Unit RF28 also includes 7.2 rkm (4.5 rmi) of the Middle Branch North Fork Vermilion River from the Jordan Creek confluence northwest of Alvin, Illinois, downstream to its confluence with North Fork Vermilion River west of Alvin, Vermilion County, Illinois. The rabbitsfoot in the North Fork Vermilion River is considered a metapopulation with the Middle Branch North Fork Vermilion River population (Butler 2005, p. 47). This unit contains all or some components of all four physical or biological features, including connectivity between North Fork Vermilion River and Middle Branch North Fork Vermilion River. This unit contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above and channelization and row crop agriculture. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF29: Fish Creek—Williams County, Ohio. Unit RF29 includes 7.7 rkm (4.8 rmi) of Fish Creek from the Indiana and Ohio State line northwest of Edgerton, Ohio, downstream to its confluence with the St. Joseph’s River north of Edgerton, Williams County, Ohio. This unit contains all or some components of all four physical or biological features and sustains genetic diversity and historical distribution as the only remaining rabbitsfoot population in the Great Lakes sub-basin. This unit contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above as well as row crop agriculture and confined animal operations (hogs). Approximately 90 percent of the riparian lands adjacent to, but not included in, this unit are in private ownership and 10 percent are in State or local ownership.

Unit RF30: Red River—Logan County, Kentucky; and Montgomery and Robertson Counties, Tennessee. Unit RF30 includes 50.2 rkm (31.2 rmi) of the Red River from the South Fork Red River confluence west of Adairville, Kentucky, downstream to the Sulphur Fork confluence southwest of Adams, Tennessee. This unit contains all or some components of all four physical or biological features and sustains genetic diversity and historical distribution as the largest of two remaining rabbitsfoot populations within the Cumberland River basin. This unit contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protection to address changes described above as well as row crop agriculture and channelization. All riparian lands adjacent to, but not included in, this unit are in private ownership.

Unit RF31: Shenango River—Mercer County, Pennsylvania. Unit RF31 includes 24.8 rkm (15.4 rmi) of the Shenango River from Porter Road near Greenville, Pennsylvania, downstream to the point of inundation by Shenango River Lake near Big Bend, Mercer County, Pennsylvania. This unit contains all or some components of all four physical or biological features and contains all five primary constituent elements. The physical or biological features in this unit may require special management considerations or protections to address changes described above as well consumptive water uses. Approximately 54 percent of the riparian lands adjacent to, but not included in, this unit are in Federal ownership and 46 percent are in private ownership.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the rabbitsfoot consist of five components:

(i) Geomorphically stable river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with habitats that support a diversity of freshwater mussel and native fish (such as stable riffles, sometimes with runs, and mid-channel island habitats that provide flow refuges consisting of gravel and sand substrates with low to moderate amounts of fine sediment and attached filamentous algae).

(ii) A hydrologic flow regime (the severity, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for maintenance of the mussel's and fish host's habitat, food availability, spawning habitat for native fishes, and the ability for newly transformed juveniles to settle and become established in their habitats.

(iii) Water and sediment quality (including, but not limited to, conductivity, hardness, turbidity, temperature, pH, ammonia, heavy metals, and chemical constituents) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages.

(iv) The occurrence of natural fish assemblages, reflected by fish species richness, relative abundance, and community composition, for each inhabited river or creek that will serve as an indication of appropriate presence and abundance of fish hosts necessary for recruitment of the rabbitsfoot. Suitable fish hosts for rabbitsfoot may include, but are not limited to, blacktail shiner (Cyprinella venusta) from the Black and Little River and cardinal shiner (Luxilus cardinalis), red shiner (C. lutrensis), spotfin shiner (C. spiloptera), bluntface shiner (C. camura), rainbow darter (Etheostoma caeruleum), rosyface shiner (Notropis rubellus), striped shiner (L. chrysocephalus), and emerald shiner (N. atherinoides).

(v) Competitive or predaceous invasive (nonnative) species in quantities low enough to have minimal effect on survival of freshwater mussels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as dams, piers and docks, bridges, or other similar structures) within the legal boundaries on June 1, 2015.

Special management considerations or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting each unit and to preserve and maintain the essential physical or biological features the critical habitat units provide to the rabbitsfoot. Examples of special management actions that would minimize or ameliorate threats imposed by impoundments include: (a) Modified reservoir releases from dams to improve water quality and habitat conditions in many tailwaters, and (b) modified dam operations (for example, TVA's Tims Ford Dam on the Elk River, where water temperature is monitored and dam operation is adjusted to support endangered mussels downstream) and water quality and biological monitoring. Examples of special management actions that would minimize or ameliorate threats imposed by channelization include: (a) Determining distribution and abundance of mussels, (b) developing dredging protocols and mussel identification booklets to help minimize effects (for example, ACOE–Memphis District in the White River avoids dredging known mussel beds), and (c) funding research on geomorphological requirements of mussels to better inform management decisions. Examples of special management actions that would minimize or ameliorate threats imposed by sedimentation include: (a) Restoration and protection of riparian corridors, (b) implementation of best management practices to minimize erosion (such as State and industry practices for forestry activities), (c) stream bank restoration projects, and (d) private landowner programs to promote watershed and soil conservation. Examples of special management actions that would minimize or ameliorate threats imposed by chemical contaminants include: (a) Revising water quality standards (such as EPA's new ammonia aquatic life criteria), (b) implementing storm water best management practices, (c) promoting green areas along riparian corridors in rapidly developing urban areas (such as the Illinois River), (d) upgrading industrial and municipal treatment facilities to improve water quality in effluents, and (e) participating in private landowner programs to promote watershed conservation (such as USDA Farm Bill programs). Examples of special management actions that would minimize or ameliorate threats imposed by mining include: (a) Remediating soils contaminated with heavy metals (such as Tri-State Mining Area's reclamation of contaminated areas to improve water quality), and (b) partnering with industry to identify mussel locations to avoid during instream and alluvial sand and gravel mining operations. Examples of special management actions that would minimize or ameliorate threats imposed by oil and natural gas development include: (a) Developing and implementing best management practices for oil and natural gas development activities (such as Fayetteville Shale located in the upper Little Red River watershed), (b) partnering with industry and nongovernmental organizations to restore mussel habitat (such as Southwestern Energy's ECH20 (Energy Conserving Water) and the Archey Fork Little Red River Restoration Project), (c) creating conservation memoranda of agreement with industry to conserve mussel habitat (such as Crestwood Midstream in the upper Little Red River watershed), and (d) developing ecologically sustainable flow requirements for mussels. Examples of special management actions that would minimize or ameliorate threats imposed by invasive, nonindigenous species include: (a) Implementation of nonregulatory conservation measures to control Asian carp and other invasive, nonindigenous species, and (b) continued State engagement in efforts to minimize effects of Asian carp (such as eradication) on native fish resources. Examples of special management actions that would minimize or ameliorate threats imposed by temperature include: (a) Increase cold water temperature to optimal range for mussels by modification to tailwater releases, (b) improve industrial and municipal water treatment, and (c) protect and restore riparian habitat. Examples of special management actions that would minimize or ameliorate threats imposed by climate change include: (a) Reduce habitat fragmentation; (b) maintain ecosystem function and resiliency; (c) develop and implement strategies to help our native fish, wildlife, and habitats adapt to a changing climate; and (d) reduce nonclimate stressors.

Life History

Feeding Narrative

Adult: Food items include algae, bacteria, detritus (disintegrated organic debris), and microscopic animals (Strayer et al. 2004, pp. 430–431). It also has been surmised that dissolved organic matter may be a significant source of nutrition (Strayer et al. 2004, p. 430). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column. Juveniles typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994, pp. 200–221; Gatenby et al. 1996, p. 604). Heavy-shelled species, such as the rabbitsfoot, grow slowly relative to thin-shelled species (Coon et al. 1977, pp. 19–21; Hove and Neves 1994, p. 38) (USFWS, 2012).

Reproduction Narrative

Adult: Yeager and Neves (1986) subjectively aged (by counting external growth rings) the rough rabbitsfoot to 22 years, and Henley et al. (no date, p. 16) objectively aged (by thin-sectioning shells) a specimen at 63 years. Anthony et al. (2001) surmised that growth ring counts, however, may not be annual and that counts may actually be underestimating longevity by a factor of 3 to 10. Age at sexual maturity for the rabbitsfoot is 4 to 6 years for populations in the upper Arkansas, White, and Red River Systems (Fobian, 2007) (NatureServe, 2015). Suitable fish hosts for rabbitsfoot populations west of the Mississippi River include blacktail shiner (Cyprinella venusta) from the Black and Little River and cardinal shiner (Luxilus cardinalis), red shiner (C. lutrensis), spotfin shiner (C. spiloptera), and bluntface shiner (C. camura) from the Spring River, but host suitability information is lacking for the eastern range (Fobian 2007, p. ii). In addition, rosyface shiner (Notropis rubellus), striped shiner (L. chrysocephalus), and emerald shiner (N. atherinoides) served as hosts for rabbitsfoot, but not in all stream populations tested (Fobian 2007, p. 69). It is a short–term brooder, with females brooding between May and late August (Fobian 2007, pp. 15–16). Fecundity in river basins west of the Mississippi River ranged from 46,000 to 169,000 larvae per female (Fobian 2007, p. 19) (USFWS, 2012).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear, fragmented (USFWS, 2012)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: According to Gordon and Layzer (1989) the typical habitat for this species is small to medium rivers with moderate to swift currents, and in smaller streams it inhabits bars or gravel and cobble close to the fast current. Found in medium to large rivers in sand and gravel (Cummings and Mayer, 1992). It has been found in depths up to 3 m (Parmalee, 1967). Despite their streamlined appearance, specimens are more often found fully exposed lying on their sides on top of the substrate (Walters, pers. obs.). Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls. It is moderatley vulnerable to extirpation and has a narrow environmental specificity (NatureServe, 2015). In streams where it remains extant, populations are highly fragmented and restricted to short reaches (USFWS, 2012).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Number of Populations:

63 (USFWS, 2020)

Population Narrative:

We considered populations of the Rabbitsfoot extant in 63 of 148 (43%) rivers or creeks. Fourteen of these populations (24%) are stable or improving and 7 declining (11%). The status of 41 (65%) extant populations is unknown due to no new information since publication of the proposed listing rule (Table 1). Reservoir construction isolated most populations within river basins from each other. These results demonstrate a need to conduct more surveys to assess status of populations of the Rabbitsfoot. Individuals are widely scattered in isolated concentrations with low abundance in many extant populations with few exceptions (e.g. Green River, Little River). (USFWS, 2020)

Threats and Stressors

Stressor: Impoundments (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Dams eliminate and alter river flow within impounded areas, trap silt leading to increased sediment deposition, alter water quality, change hydrology and channel geomorphology, decrease habitat heterogeneity, affect normal flood patterns, and block upstream and downstream movement of mussels and fish (Layzer et al. 1993, pp. 68–69; Neves et al. 1997, pp. 63–64; Watters 2000, pp. 261–264). Within impounded waters, decline of mussels has been attributed to direct loss of supporting habitat, sedimentation, decreased dissolved oxygen, temperature levels, and alteration in resident fish populations (Neves et al. 1997, pp. 63–64; Pringle et al. 2000, pp. 810–815; Watters 2000, pp. 261–264). Dam construction has a secondary effect of fragmenting the ranges of mussel species by leaving relict habitats and populations isolated upstream or between structures as well as creating extensive areas of deep uninhabitable, impounded waters (USFWS, 2012).

Stressor: Channelization (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Channelization affects a stream physically (accelerates erosion, increases sediment bed load, reduces water depth, decreases habitat diversity, creates geomorphic (natural channel dimensions) instability, eliminates riparian canopy) and biologically (decreases fish and mussel diversity, changes species composition and abundance, decreases biomass, and reduces growth rates) (Hartfield 1993, pp. 131–139). Channel modification for navigation has been shown to increase flood heights (Belt 1975, p. 684), partly as a result of an increase in stream bed slope (Hubbard et al. 1993, p. 137). Channel and bank degradation have led to the loss of stable substrates in numerous rivers with commercial navigation throughout the range of rabbitsfoot (USFWS, 2012).

Stressor: Sedimentation (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Adverse effects resulting from sediments have been noted for many components of aquatic communities. Potential sediment sources within a watershed include virtually all activities that disturb the land surface. Most localities occupied by the rabbitsfoot, including viable populations, are currently being affected to varying degrees by sedimentation. Sedimentation has been implicated in the decline of mussel populations nationwide, and remains a threat to the rabbitsfoot (Ellis 1936, pp. 39–40; Vannote and Minshall 1982, pp. 4105–4106; Dennis 1984, p. 212; Brim Box and Mosa 1999, p. 99; Fraley and Ahlstedt 2000, pp. 193–194; Poole and Downing 2004, pp. 119–122). Specific biological effects include reduced feeding and

respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, limited burrowing activity, physical smothering, and disrupted host fish attraction mechanisms (Ellis 1936, pp. 39–40; Marking and Bills 1979, p. 210; Vannote and Minshall 1982, pp. 4105–4106; Waters 1995, pp. 173–175; Hartfield and Hartfield 1996, p. 373). In addition, mussels may be indirectly affected if high turbidity levels significantly reduce the amount of light available for photosynthesis, and thus, the production of certain food items (Kanehl and Lyons 1992, p. 7) (USFWS, 2012).

Stressor: Chemical contaminants (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Chemicals enter the environment through point and nonpoint discharges including spills, industrial and municipal effluents, and residential and agricultural runoff. These sources contribute organic compounds, heavy metals, nutrients, pesticides, and a wide variety of newly emerging contaminants such as pharmaceuticals to the aquatic environment. As a result, water and sediment quality can be degraded to the extent that results in adverse effects to mussel populations (USFWS, 2012).

Stressor: Mining (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Instream and alluvial gravel mining has been implicated in the destruction of mussel populations (Hartfield 1993, pp. 136–138; Brim Box and Mossa 1999, pp. 103–104). Negative effects associated with gravel mining include stream channel modifications (altered habitat, disrupted flow patterns, sediment transport), water quality modifications (increased turbidity, reduced light penetration, increased temperature), macroinvertebrate population changes (elimination), and changes in fish populations, resulting from adverse effects to spawning and nursery habitat and food web disruptions (Kanehl and Lyons 1992, pp. 4–10). Gravel mining activities continue to be a localized threat in several streams with viable rabbitsfoot populations (Ohio, Tennessee, White, Strawberry, and Little Rivers). Coal mining activities, resulting in heavy metal-rich drainage, and associated sedimentation has adversely affected many drainages with rabbitsfoot populations, including portions of the upper Ohio River system in Kentucky, Pennsylvania, and West Virginia; the lower Ohio River system in eastern Illinois; the Rough River drainage in western Kentucky; and the upper Cumberland River system in Kentucky and Tennessee (Ortmann 1909 in Butler 2005, p. 102; Gordon 1991, pp. 4 and 5; Layzer and Anderson 1992 in Butler 2005, p. 102). Metal mining (lead, cadmium, and zinc) in the Tri-State Mining Area (15,000 km2; 5,800 mi2 in Kansas, Missouri, and Oklahoma) has adversely affected Center and Shoal Creeks and the Spring River. It has been implicated in the loss of rabbitsfoot from portions of these streams (Obermeyer et al. 1997b, p. 114) (USFWS, 2012).

Stressor: Oil and natural gas development (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Exploration and extraction of these energy resources can result in increased siltation, a changed hydrograph (graph showing changes in the discharge of a river over a period of time),

and altered water quantity and quality even at considerable distances from the mine or well field because effects are carried downstream from the original source. Rabbitsfoot habitat in streams can be threatened by the cumulative effects of multiple mines and well fields (adapted from Service 2008, p. 11) (USFWS, 2012).

Stressor: Population fragmentation and isolation (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Population fragmentation and isolation prohibit the natural interchange of genetic material between populations. Most of the remaining rabbitsfoot populations are small and geographically isolated, and, thus, are susceptible to genetic drift, inbreeding depression, and stochastic changes to the environment, such as toxic chemical spills (Smith 1990, pp. 311–321; Watters and Dunn 1995, pp. 257–258; Avise and Hamrick 1996, pp. 463–466). Inbreeding depression can result in early mortality, decreased fertility, smaller body size, loss of vigor, reduced fitness, and various chromosome abnormalities (Smith 1990, pp. 311– 321) (USFWS, 2012).

Stressor: Invasive nonindigenous species (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The nonnative, invasive species that poses the most significant threat is the zebra mussel, Dreissena polymorpha, introduced from Europe. Zebra mussels attach in large numbers to the shells of live native mussels and are implicated in the loss of entire native mussel beds. Fouling effects include impeding locomotion (both laterally and vertically), interfering with normal valve movements, deforming valve margins, and locally depleting food resources and increasing waste products. The Asian clam (Corbicula fluminea) has spread throughout the range of the rabbitsfoot since its introduction in the early twentieth century. It competes with native mussels, particularly juveniles, for resources such as food, nutrients, and space (Neves and Widlak 1987, p. 6; Leff et al. 1990, p. 414), and may ingest sperm, glochidia, and newly metamorphosed juveniles of native mussels (Strayer 1999b, p. 82; Yeager et al. 2000, p. 255). A molluscivore (mollusk eater), the introduced black carp (Mylopharyngodon piceus), is a potential threat to the rabbitsfoot (Strayer 1999b, p. 89). It has been proposed for widespread use by aquaculturists to control snails, the intermediate host of a trematode (flatworm) parasite affecting catfish in ponds in the southeast and lower midwest. They are known to feed on various mollusks, including mussels and snails, in China. The round goby (Neogobius melanostomus) is another nonnative, invasive fish species released in the 1980s that is well established and likely to spread through the Mississippi River system (Strayer 1999b, pp. 87–88). This species is an aggressive competitor of similar-sized benthic fishes (sculpins and darters), as well as a voracious carnivore, despite its size (less than 25.4 cm (10 in.) in length), preying on a variety of foods, including small mussels and fishes that could serve as glochidial hosts (Strayer 1999b, p. 88; Janssen and Jude 2001, p. 325) (USFWS, 2012).

Stressor: Climate change (USFWS, 2012)
Exposure:
Response:
Consequence:

Narrative: Projections for the change in annual air temperature by the year 2080 for the rabbitsfoot anticipate an increase of 4.5 to 8 degrees F in annual air temperature (Maura et al. 2007, as displayed on http:// www.climatewizard.org/# 2012). Ficke et al. (2005, pp. 67–69; 2007, pp. 603–605) described the general potential effects of climate change on freshwater fish populations worldwide. Overall, the distribution of fish species is expected to change, including range shifts and local extirpations. Because freshwater mussels are entirely dependent upon a fish host for successful reproduction and dispersal, any changes in local fish populations would also affect freshwater mussel populations (USFWS, 2012).

Recovery

Reclassification Criteria:
Recovery Priority Number: 12

Delisting Criteria:
1. Watersheds identified in Criterion 3 support the resource needs necessary for each life history stage of the Rabbitsfoot, such as appropriate flows, water quality, spawning temperatures, substrate for juvenile settlement and adult survival, food availability, and sufficient abundance of host fish necessary for recruitment (Service 2021 pp. 14–17; Factors A, D, and E) (USFWS, 2023).

2. Range-wide threats identified in the Species Status Assessment (Service 2021, pp. 20-33) have been addressed to the extent that hydrologic alteration, erosion and sedimentation, climate change, nutrient and chemical pollution, and density of developed land use, as well as local scale threats such as mining and invasive species, have been eliminated and/or abated to the extent necessary to maintain resiliency, redundancy, and representation (Service 2021, pp. 57-63; Factors A, D, and E). Examples of addressing and measuring current and foreseeable threats to the Rabbitsfoot include: a. Hydrologic Alteration: flows in regulated rivers with designated critical habitat are managed according to conditions well suited for recruitment and survival of the Rabbitsfoot. b. Erosion and Sedimentation: environmentally sensitive best management practices for erosion control, stormwater control, and riparian habitat protection are widely adopted with a successful track record for implementation in watersheds necessary for recovery. c. Nutrient and Chemical Pollution: regulatory thresholds for water quality that are protective of freshwater mussels are enacted and enforced; water quality classifications are changed to prevent future adverse effects to critical habitat; mining effects are mitigated to levels necessary to support recruitment and survival of the Rabbitsfoot. d. Climate Change: sufficient data, data collection tools, and predictive models are in place to allow for accurate forecasting of climate (e.g., precipitation and water temperature) conditions relevant to recruitment and survival of the Rabbitsfoot; robust predictive models and appropriate actions are incorporated into management and regulatory mechanisms for the Rabbitsfoot. e. Density of Developed Land Use: sufficient data, data collection tools, and predictive models are in place to allow for accurate forecasting of future land use conditions related to recruitment and survival of the Rabbitsfoot; occupied habitats that are most vulnerable to future urbanization of land use effects are identified and protected; local ordinances are enacted and enforced in developing watersheds with critical habitat to buffer against adverse effects associated with urbanization. Through protection and/or improvement of habitat in extant watersheds, successful establishment of reintroductions in watersheds currently classified as extirpated or unknown condition or the discovery of additional extant watersheds, seven of nine

representation units contain 95 to 103 watersheds that maximize the probability of persistence (resiliency; Table 1) and geographic extent (representation) for specific watersheds (redundancy) (Service 2021, pp. 57–63; Factors A and E). This criterion is based on the best available information and professional judgment of species experts. It may be revised based on additional biological, demographic, or genetic information obtained through recovery actions (USFWS, 2023).

3.1 Arkansas River 3.1.1 Seven of nine Neosho River watersheds downstream of John Redmond Reservoir are in medium or high condition. 3.1.2 Three of five Spring River and North Fork Spring River watersheds are in medium or high condition, with at least one watershed in high condition. 3.2 Cumberland River 3.2.1 Three of four Red River watersheds in medium or high condition, with at least two in high condition. 3.2.2 Two watersheds on Rockcastle River closest to its confluence with the Cumberland River in at least medium condition. 3.3 Lower Great Lakes 3.3.1 Upper St. Joseph’s River watersheds in at least medium condition, with Fish Creek watershed in high condition. 3.4 Lower Mississippi River 3.4.1 At least one watershed in high and four in medium condition in the St. Francis River. 3.5 Lower Ohio River 3.5.1 Green River with at least two high condition watersheds, four medium condition watersheds, and two low condition watersheds. At least three watersheds in four of the Green River tributary watersheds (Nolin, Rough, and Barren rivers, and Russell Creek) in medium or high condition. 3.5.2 Ohio River from Green River confluence upstream to Cannelton Lock and Dam with at least one watershed in high and one in medium condition. 3.5.3 Ohio River from Smithland Lock and Dam to Lock and Dam 53 with at least two watersheds in high and one watershed in medium condition. 3.5.4 The North Fork Vermilion and Middle Branch North Fork Vermilion rivers in high or medium condition. 3.5.5 At least five watersheds in the Tippecanoe River in high condition. 3.5.6 At least three watersheds in the Scioto River, Olentangy River, and/or Big Darby and Little Darby creeks in at least medium condition. 3.6 Upper Ohio River 3.6.1 French Creek watershed in high condition, and LeBoeuf and Muddy creek watersheds, tributaries of French Creek, in at least low condition. 3.6.2 Upper and lower Allegheny River watersheds are in at least medium condition. 3.6.3 Both Shenango River watersheds in at least medium condition. 3.6.4 Walhonding River watershed in high condition, including the Mohican River and Muskingum River watershed at the convergence with the Walhonding River in at least medium condition and Tuscarawas River watersheds in at least medium condition. 3.6.5 Pymatuning Creek watershed in at least medium condition. 3.7 Tennessee River 3.7.1. Tennessee River watersheds downstream of Pickwick Landing and Kentucky Lake dams in high condition. 3.7.2 Two of five Duck River watersheds in high condition and two in medium condition and the Lower Buffalo River watershed, a tributary of the Duck River, in at least medium condition. 3.7.3 At least one Elk River watershed in high condition and two of three remaining watersheds in medium condition. 3.7.4 Paint Rock River watersheds in high condition. 3.7.5 Bear Creek watershed at its confluence with the Tennessee River in high condition and the other in medium condition. 3.8 Red River 3.8.1 The two Little River watersheds immediately upstream of Millwood Lake are in high condition and at least one other watershed in medium condition. At least two Little River tributary watersheds (Glover, Rolling Fork, Cossatot, and Saline rivers) are in low condition. 3.8.2 Two of five Ouachita River watersheds between Malvern and Camden, Arkansas, in high condition; two of five watersheds in medium condition. Two lower Little Missouri River watersheds in medium condition. 3.8.3 Three of six Saline River watersheds in high condition; two of six watersheds in medium condition. 3.8.4 Bayou Bartholomew watershed in Louisiana in high condition. 3.9 White River 3.9.1 War Eagle Creek watershed in high condition. 3.9.2 Two of four Buffalo River watersheds in high condition; two of four in medium condition. 3.9.3 Lower

Middle Fork Little Red River watershed in high condition. 3.9.4 Strawberry River watersheds in high condition. 3.9.5 Lower Spring River watershed in high condition; South Fork Spring River watershed in medium condition (USFWS, 2023).

Recovery Actions:

- 1. Protect and improve habitat to maintain and increase resiliency (USFWS, 2023).
- 2. Maximize viability by reintroduction and augmentation efforts through propagation (USFWS, 2023).
- 3. Increase knowledge of the biology of the species and the ecological factors affecting it (USFWS, 2023).
- 4. Evaluate taxonomic uncertainty and genetic structure of populations (USFWS, 2023).
- 5. Monitor population and habitat conditions across historical range (USFWS, 2023).
- 6. Develop and implement strategies to prevent the spread of invasive nonnative species (USFWS, 2023).
- 7. Periodically review recovery progress and update recovery plan as needed (USFWS, 2023).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS We arranged the following recommendations for future conservation actions by general priority. 1. Conduct a genetics study to evaluate the taxonomic validity of Theliderma cylindrica to determine whether the Service moves forward with recovery planning and implementation for 1 (Theliderma cylindrica) or more (e.g., Quadrula cylindrica cylindrica and Quadrula cylindrica strigillata) mussel species. 2. Complete a recovery plan. 3. Restore degraded habitat with a focus on areas designated as critical habitat. 4. Implement watershed habitat improvement and protection of critical habitat. 5. Fund and implement a rangewide genomics project to inform propagation and reintroduction efforts. 6. Develop and implement a plan for propagation and reintroduction. 7. Conduct priority research once identified in the recovery plan. 8. Develop and implement a monitoring protocol to assess status rangewide at an appropriate interval or as necessary to accomplish management needs. 9. Implement and enforce programs to minimize spread of invasive or non-native mussel and fish species that compete with native freshwater mussels (USFWS, 2020)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

U.S. Fish and Wildlife Service. 2015. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Neosho Mucket and Rabbitsfoot. Final rule. 80 FR 24691 - 24774 (April 30, 2015).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2012. Endangered and Threatened Wildlife and Plants

Proposed Endangered Status for the Neosho Mucket, Threatened Status for the Rabbitsfoot, and Designation of Critical Habitat for Both Species

Proposed Rule. 77 Federal Register 200. October 16, 2012. Pages 63439 - 63536.

USFWS 2013. Endangered and Threatened Wildlife and Plants

Endangered Status for the Neosho Mucket and Threatened Status for the Rabbitsfoot. 78 Federal Register 180. September 17, 2013. Pages 57076 - 57097. USFWS. 2020. Rabbitsfoot (Quadrula cylindrica cylindrica, Say 1817) 5-Year Review: Summary and Evaluation. U. S. Fish and Wildlife Service South Atlantic-Gulf & Mississippi-Basin Unified Interior Regions Arkansas Ecological Services Field Office Conway, Arkansas. 107 pp.

USFWS. 2012. Endangered and Threatened Wildlife and Plants

USFWS. 2023. Recovery Plan for the Rabbitsfoot (Quadrula cylindrica cylindrica). Atlanta, Georgia. 11 pp.

USFWS. 2020. Rabbitsfoot (Quadrula cylindrica cylindrica, Say 1817) 5-Year Review: Summary and Evaluation. U. S. Fish and Wildlife Service South Atlantic-Gulf & Mississippi-Basin Unified Interior Regions Arkansas Ecological Services Field Office Conway, Arkansas. 107 pp.

SPECIES ACCOUNT: *Quadrula cylindrica strigillata* (Rough rabbitsfoot)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The rough rabbitsfoot has an elongated, heavy, highly pustulate (bumpy) shell. Some specimens may have low knobs on the posterior slope. The periostracum is yellowish to greenish in color and is covered with green rays, blotches, and chevron patterns. The nacre is silvery to white with iridescence in the posterior area of the shell.

Taxonomy

The tendency for the shell to be compressed, highly pustulate, and have low to no knobs on the posterior ridge distinguishes this morph from Quadrula cylindrica s. s. [i.e., Q. c. cylindrica (Say, 1817), rabbitsfoot]. It is not easily confused with any other sympatric species.

Historical Range

The historical distribution of this taxon is generally considered to be above the Norris Reservoir (Powell and Clinch Rivers) and in the North Fork and South Fork of the Holston River in northeastern Tennessee and southwestern Virginia (Ortmann 1918). Downstream (main stem of the Tennessee River and larger tributaries), the typical form (Quadrula c. cylindrica) is presumed to have occurred. The rough rabbitsfoot is restricted to the upland-most portion of the Ridge and Valley Physiographic Province, making it one of the more narrowly distributed species endemic to the Cumberlandian Region.

Current Range

Populations of this species remain in the Clinch River in Russell, Scott, and (possibly) Tazewell Counties (but see Table 5, Footnote 1), Virginia, and Hancock County, Tennessee; Indian Creek, Tazewell County, Virginia; and the Powell River, Lee County, Virginia, and Hancock and Claiborne Counties, Tennessee.

Distinct Population Segments Defined

not applicable

Critical Habitat Designated

Yes; 8/31/2004.

Legal Description

On August 31, 2004, the U.S. Fish and Wildlife Service (Service), designated river and stream segments (units) in the Tennessee and/or Cumberland River Basins as critical habitat for the rough rabbitsfoot (Quadrula cylindrica strigillata) under the Endangered Species Act of 1973, as amended (69 FR 53136 - 53180).

Critical Habitat Designation

Critical habitat for the rough rabbitsfoot is designated in Powell River (Unit 4), TN, VA; Clinch River (Unit 5), TN, VA; Copper Creek (Unit 5), VA; and Indian Creek (Unit 5), VA.

Unit 4. Powell River, Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia. Unit 4 encompasses 154 rkm (94 rmi) and includes the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. This reach is currently occupied by the Cumberlandian combshell (Ahlstedt 1991b; Gordon 1991) and rough rabbitsfoot (Service 2004), and was historically occupied by the oyster mussel (Wolcott and Neves 1990) and the purple bean (Ortmann 1918). It is also existing critical habitat for the federally listed slender chub and yellowfin madtom.

Unit 5. Clinch River and tributaries, Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia. Unit 5 totals 272 rkm (171 rmi), including 242 rkm (148 rmi) of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia; 4 rkm (2.5 rmi) of Indian Creek from its confluence with the Clinch River upstream to the fourth Norfolk Southern Railroad crossing at Van Dyke, Tazewell County, Virginia; and 21 rkm (13 rmi) of Copper Creek from its confluence with the Clinch River upstream to Virginia State Route 72, Scott County, Virginia. The Clinch River main stem currently contains the oyster mussel, rough rabbitsfoot, Cumberlandian combshell, and purple bean (Gordon 1991; Ahlstedt and Tuberville 1997; S.A. Ahlstedt, pers. comm. 2002). Indian Creek currently supports populations of the purple bean and rough rabbitsfoot (Winston and Neves 1997; Watson and Neves 1996). Copper Creek is currently occupied by a low-density population of the purple bean and contains historical records of both the oyster mussel and rough rabbitsfoot (Ahlstedt 1981; Fraley and Ahlstedt 2001; S.A. Ahlstedt, pers. comm. 2003). Copper Creek is critical habitat for the yellowfin madtom and a portion of the Clinch River main stem section is critical habitat for both the slender chub and the yellowfin madtom.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the rough rabbitsfoot (Quadrula cylindrica strigillata) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the five mussels and their host fish;

(ii) Geomorphically stable stream and river channels and banks;

(iii) Stable substrates consisting of mud, sand, gravel, and/or cobble/ boulder, with low amounts of fine sediments or attached filamentous algae;

(iv) Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and

(v) Fish hosts with adequate living, foraging, and spawning areas for them.

Special Management Considerations or Protections

All critical habitat units identified may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, or presence of fish hosts. All of these units are threatened by actions that alter the stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); and point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation. Habitat fragmentation, population isolation, and small population size compounds these threats to the species. Various activities in or adjacent to each of the critical habitat units may affect one or more of the primary constituent elements that are found in the unit.

Life History

Feeding Narrative

Larvae: The Rough Rabbitsfoot relys on hosts (Hybopsis amblops (Rafinesque, 1820), Notropis galacturus (Cope, 1868), and Notropis spilopterus (Cope, 1868)).

Juvenile: Juvenile mussels employ foot (pedal) feeding and are thus suspension/deposit feeders (Yeager et al. 1994). The juvenile diet (up to 2 weeks of age) includes bacteria, algae (i.e., nonfilamentous, non-blue green), and diatoms, with some detrital and inorganic colloidal particles (Yeager et al. 1994).

Adult: Adult freshwater mussels are filter feeders, orienting themselves in the substrate to facilitate the siphoning of the water column for oxygen and food (Kraemer 1979). Specific food habits of the oyster mussel is unknown, but they likely ingest food items similar to those consumed by other riverine mussels. Mussels are known to consume bacteria, detritus, assimilated organic material, diatoms, phytoplankton, zooplankton, phagotrophic protozoans, and other microorganisms (Coker et al. 1921, Churchill and Lewis 1924, Ukeles 1971, Fuller 1974, Baldwin and Newell 1991, Neves et al. 1996).

Reproduction Narrative

Adult: Yeager and Neves (1986) summarized the reproductive biology and identified fish hosts of the unionine rough rabbitsfoot. Spawning occurred from May through June (water temperature 68.0° to 71.6°F). Fertilization success was high (>95 percent) through late June, but by July only unfertilized ova were found. Unlike most unionines, 65 percent of 82 gravid females examined utilized only the outer demibranchs as marsupia. They estimated gravidity rates (30 to 60 percent) peaked in late May then gradually declined. Females release lanceolate-shaped whitish to reddish brown conglutinates (0.4 inch long) that contain 375 to 505 semicircular-shaped glochidia. Fecundity was estimated at 115,000 embryos per female. The age of gravid females was qualitatively estimated to be 10 to 22 years. Three cyprinid host fish species have been identified--the whitetail shiner, spotfin shiner (C. spiloptera), and bigeye chub (Hybopsis amblops). Infestation rates ranged from as few as five to ten glochidia on individual fishes. Transformation took from 13 to 23 days, at 68.9° to 71.4°F.

Geographic or Habitat Restraints or Barriers

Larvae: impoundments

Juvenile: impoundments

Adult: impoundments

Spatial Arrangements of the Population

Larvae: clumped according to suitable resources

Juvenile: clumped according to suitable resources

Adult: clumped according to suitable resources

Environmental Specificity

Larvae: specialist, depends on a host

Juvenile: generalist

Adult: generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality degradation

Juvenile: likely low; sensitive to water quality degradation

Adult: likely low; sensitive to water quality degradation

Site Fidelity

Larvae: dependent on host

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: Hybopsis amblops (Rafinesque, 1820), Notropis galacturus (Cope, 1868), and Notropis spilopterus (Cope, 1868)

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Adult mussels are ideally found in localized patches (beds) in streams, almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Vannote and Minshall 1982, Neves and Widlak 1987, Leff et al. 1990, Strayer 1997). Physical qualities of the sediment (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediment, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999). Water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams (Huehner 1987). The Rough Rabbitsfoot inhabits medium-sized to large rivers in moderate to swift current but often exists in areas close to, but not in, the swiftest current (Gordon 1991). It is reported to live in silt, sand, gravel, or cobble in eddies at the edge of midstream currents and may be associated with macrophyte beds (Yeager and Neves 1986, Gordon 1991). The rough rabbitsfoot seldom burrows; it generally lies on its side on the stream bottom (Neves, pers. comm., 2003).

Dispersal/Migration

Motility/Mobility

Larvae: Dependent on host

Juvenile: Limited; passive movement via flushing event

Adult: Limited; passive movement via flushing event

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Non-migratory

Adult: Non-migratory

Dispersal

Juvenile: Limited; passive movement via flushing event

Adult: Limited; passive movement via flushing event

Dependency on Other Individuals or Species for Dispersal

Larvae: yes; host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Primary dispersal of the Rough rabbitsfoot is likely via through host.

Juvenile: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Adult: Mostly sessile with limited movement through the substrates, but may be dislodged during flood events and move passively.

Population Information and Trends

Population Trends:

Declining

Species Trends:
Declining

Population Growth Rate:
have decreased 70 to 90 percent

Population Size:
2500 - 10,000 individuals

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Populations have and continue to decline dramatically (70-90%).

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The decline, extirpation, and extinction of mussel species is overwhelmingly attributed to habitat alteration and destruction (Neves 1993), primarily manifest in the conversion of riverine systems to impoundments (Yeager 1993 1994). Impoundments, especially large main-stem reservoirs, have significantly altered riverine ecosystems (Baxter and Glaude 1980, Williams et al. 1992, Allan and Flecker 1993, Ligon et al. 1995, Sparks 1995) and have been a major factor in the high extinction rate oof freshwater mollusks (Johnson 1978, Lydeard and Mayden 1995, Neves et al. 1997). Impoundments result in the elimination of riffle and shoal habitats and the subsequent loss of mussel resources (Ortmann 1925; van der Schalie 1938; Scruggs 1960; Bates 1962; Neel 1963; Isom 1969, 1971; Stansbery 1970, 1973b; Fuller 1974; Schmidt et al. 1989; Williams et al. 1992; Layzer et al. 1993; Parmalee and Hughes 1993; Lydeard and Mayden 1995; Sickel and Chandler 1996; Watters 1996). Most of a river's ecological processes are also disrupted, for example, by modifying flood pulses; controlling impounded water elevations; increasing depth; decreasing habitat heterogeneity; altering water flow, sediment, nutrients, energy input and output, and the riverine biota; and causing the loss of bottom stability due to subsequent sedimentation (Williams et al. 1992, Ligon et al. 1995, Sparks 1995, Watters 2000). The elimination of current and the covering of rocky and sand substrates by fine sediments alters the habitat of riverine species (including these five, typically shoal-inhabiting, species) to the point where they can no longer reproduce, recruit, and survive under impoundment conditions (Fuller 1974, Neves et al. 1997, Hughes and Parmalee 1999). In addition, dams can seriously alter downstream water quality and riverine habitat (Allan and Flecker 1993, Ligon et al. 1995, Collier et al. 1996) and negatively impact mussel populations in tailwaters (Cahn 1936b, Hickman 1937,

Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999, McMurray et al. 1999b, Vaughn and Taylor 1999). These changes include thermal alterations (Neves 1993), channel characteristics, habitat availability, and flow regimes that have drastic effects on the stream biota (Krenkel et al. 1979, Allan and Flecker 1993). Altered effects also include fish community shifts (Brim 1991) and the resultant colonization by fewer native species and more alien species (Williams and Neves 1992). Daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, cold-water releases, turbulence, high silt loads, and altered host fish distribution have contributed to limited mussel recruitment and skewed demographics (Sickel 1982, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, McMurray et al. 1999b). Cold-water releases from large nonnavigational dams are the result of placing water intake structures low on the dam to increase hydropower efficiency (Krenkel et al. 1979). The release of cold water and scouring of the riverbed from highly fluctuating, turbulent flows in tailwaters have also been implicated in the demise of Cumberlandian Region mussel faunas (Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999). Specifically, tachytictic species, which depend on warm summer temperatures to initiate gametogenesis, spawning, glochidia release, and the proper host fish being present, experience reproductive failure below dams (Heinricher and Layzer 1999). Bradytictic species are also negatively affected, and the decline of mussel populations has been manifested over a period of several decades (Neves 1999a). The mussel faunas of the middle Cumberland, lower Obey, lower Caney Fork, Little Tennessee, and Elk Rivers have been profoundly impacted by cold-water releases, including populations of the Cumberlandian combshell and oyster mussel. A reduction in water temperature, rapid changes in flow releases during hydropower peaking events, and the resultant bank sloughing and channel scouring have altered habitats so profoundly below hydroelectric dams that riverine species, including these five mussels, are unable to reproduce, recruit, and survive such conditions. The entire length of the main stems of the Tennessee and Cumberland Rivers and many of their largest tributaries are now impounded or greatly modified by the discharge of tailwaters. More than 2,300 river miles (about 20 percent) of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater were impounded by the TVA by 1971 (TVA 1971). The subsequent completion of additional major impoundments on tributary streams (e.g., Duck River in 1976, Little Tennessee River in 1979) significantly increased the total miles impounded behind the 36 major dams in the Tennessee Riversystem (Neves et al. 1997). Approximately 90 percent of the 562-mile length of the Cumberland River downstream of Cumberland Falls is either impounded (three locks anddams and the Wolf Creek Dam) or otherwise adversely impacted by cold-water discharges from the Wolf Creek Dam. Miller et al. (1984) located only two mussel specimens in a survey below the Wolf Creek Dam, which covered 68 miles of river that formerly harbored 39 species (Neel and Allen 1964). Other major U.S. Army Corps of Engineers (COE) impoundments on Cumberland River tributaries (e.g., Laurel River, Obey River, Caney Fork, Stones River) have inundated more than 125 miles of potential riverine habitat for the Cumberland elktoe, oyster mussel, and Cumberlandian combshell. Impoundments, as barriers to dispersal, contribute to the loss of local populations by blocking postextirpation recolonization (Luttrell et al. 1999). Population losses due to impoundments have probably contributed more to the decline of the Cumberlandian combshell, oyster mussel, and rough rabbitsfoot and most other Cumberlandian Region mussels than any other single factor (as the Cumberland elktoe and purple bean generally inhabit smaller rivers, impoundments have had less of an impact on them). Stream populations of these species thought to have been lost primarily or exclusively due to impoundments include the Cumberland River, Laurel River, Lynn Camp Creek, Rockcastle River, Beaver Creek, Obey River, Caney Fork, and Stones River in the Cumberland River system; and the South Fork Holston River, Holston River, Tennessee River, Little Tennessee River, Hiwassee River, Limestone Creek, Elk River, and Shoal Creek in the Tennessee River system. Reaches in other streams with extant populations of some of these species have also been destroyed by impoundments that invariably eliminated expanses of their occupied habitat (e.g., lower Big South Fork in the Cumberland River system; lower French Broad River, lower Little River [Tennessee], lower Clinch River, lower Powell River, lower Emory River, upper and lower Bear Creek, middle Duck River in the Tennessee River system). The majority of the extant populations of these species have been isolated due to impoundments (see “Patterns of Imperilment,” “Narrative Outline,” and Recovery Task 1.4.6 for a discussion of the consequences of population fragmentation), and some continue to decline and die off.

Stressor: Dredging and channelization
Exposure:
Response:
Consequence:
Narrative: Dredging and channelization activities have profoundly altered riverine habitats nationwide, with effects on streams summarized by Simons (1981), Bhowmik (1989), and Hubbard et al. (1993). DeHaan (1998) provided an annotated bibliography of sediment transport and deposition in large rivers. Hartfield (1993) and Neves et al. (1997) reviewed the specific effects of channelization on freshwater mollusks. Channelization impacts a stream’s physical (e.g., accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, riparian canopy loss) and biological (e.g., decreased fish and mussel diversity, changed species composition and abundance, decreased biomass and growth rates) characteristics (Stansbery and Stein 1971, Hartfield 1993, Hubbard et al. 1993). Since mussels need stable substrates to survive (Strayer 1999a), channel instability is probably the single most detrimental aspect of channelization (Hartfield 1993). Channel construction for navigation has been shown to increase flood heights (Belt 1975), thus exacerbating flood events that convey to streams large quantities of sediment with adsorbed contaminants. Channel maintenance may also result in downstream impacts (Stansbery 1970), such as increases in turbidity and sedimentation, which may smother benthic organisms. Impacts associated with barge traffic--the construction of fleeting areas, mooring cells, docking facilities, and propeller wash--also disrupt habitat. Although the volume of literature demonstrating the on-site and off-site environmental and economic consequences of dredging for navigation and flood control is substantial (Smith and Patrick 1991, Watters 2000), these activities continue in the Southeast. The entire length of the Tennessee River and much of the Cumberland River is maintained as a navigation channel with a series of locks and dams--nine on the Tennessee River and four on the Cumberland River. Although the dams themselves probably contributed more to the destruction of riverine habitat for mussels (including the oyster mussel and Cumberlandian combshell), channel maintenance activities continue to cause substrate instability and alteration in these rivers and may serve to diminish what habitat remains for the recovery of riverine species. Other streams, notably the lower Paint Rock River (Ahlstedt 1995-96) and portions of the Bear Creek system (McGregor and Garner, in press), have been channelized, primarily during ill-fated attempts to reduce flooding.

Stressor: Mineral extraction
Exposure:
Response:
Consequence:
Narrative: Heavy metal-rich drainage from coal mining and associated sedimentation have adversely impacted many stream reaches (Barnhisel and Massey 1969, Ahmad 1973, Curry and

Fowler 1978), destroying mussel beds and preventing natural recolonization (Simmons and Reed 1973, McCann and Neves 1992). Neves et al. (1997) reviewed the effects of various mining activities on freshwater mollusks. The low pH commonly associated with mine runoff can lead to an inability of glochidia to clamp their valves on host tissues, thus preventing proper encystment (Huebner and Pynnönen 1992). Therefore, acid mine runoff may be having local impacts on the recruitment of, particularly, the Cumberland elktoe, since most of its range is within watersheds where coal mining is still occurring. In addition, interstitial spaces in streams, which is habitat critical for juvenile mussels, are clogged by sediment runoff from mines (Branson and Batch 1972). Circumstantial evidence indicates that salinity, a by-product of oil exploration activities, is lethal to some glochidia (Liquori and Insler 1985). Increased sedimentation and turbidity, reduction in pH from chemicals associated with acid mine drainage, and heavy metals have altered habitat in many streams to the point where mussels, including these species, are unable to reproduce, recruit, and survive these conditions. Impacts associated with coal mining activities have particularly altered upper Cumberland River system streams with diverse historical mussel faunas (Stansbery 1969, Blankenship 1971, Blankenship and Crockett 1972, Starnes and Starnes 1980, Schuster et al. 1989, Anderson et al. 1991) and have been implicated in the decline of Epioblasma species, especially in the Big South Fork (Neel and Allen 1964). Strip mining continues to threaten mussels in coal field drainages of the Cumberland Plateau (Anderson 1989, Warren et al. 1999) with increased sedimentation loads and acid mine drainage, including Cumberland elktoe and Cumberlandian combshell populations. The Marsh Creek population of the Cumberland elktoe has also been adversely affected and is still threatened by potential spills from oil exploration activities. Coal mining activities also occur in portions of the upper Powell and Clinch River systems, primarily in Virginia. Scores of active and inactive mines are known from these drainages (Hampson et al. 2000). Five mine tailings pond spills were reported from 1995 to 1999 in the upper Clinch and Powell River systems (Hampson et al. 2000), at least one of which resulted in a major fish kill (Koch, pers. comm., 1996). Research by Kitchel et al. (1981) indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981). Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. Known to be toxic to mussels and fishes, PAHs have been found at relatively high levels in the upper portions of the Clinch and Powell Rivers in Virginia (Hampson et al. 2000). In fact, Hampson et al. (2000) detected 29 different PAHs in stream sediment samples in the two watersheds. The Clinch River at Pendleton Island had concentrations of two measured PAHs, naphthalene and phenanthrene, at 400 micrograms per kilogram (µg/kg) and 570 µg/kg, respectively, both of which are above the protection guidelines for aquatic life. The Canadian probable-effect levels of 391 µg/kg and 515 µg/kg, respectively, have been established for these compounds. The probable-effect levels define concentrations above which adverse effects to aquatic organisms can be expected. Pendleton Island was once a stronghold for the rough rabbitsfoot and home to the oyster mussel, Cumberlandian combshell, and purple bean as well in the early 1980s (Ahlstedt 1991a). However, the fauna there was in marked decline less than a decade later. No live oyster mussels or Cumberlandian combshells were found in 1987 (Dennis 1989). Three other sites in the Clinch River system (i.e., lower Clinch River, Guest River, Copper Creek) had concentrations of these two compounds below the probable-effect levels. A site on the Powell River near Arthur, Tennessee, had much higher levels of naphthalene and phenanthrene (1,600 µg/kg and 1,300 µg/kg, respectively) than at Pendleton Island. In the Emory River, downstream of a population of the purple bean in the Obed River, excessive naphthalene levels were detected (610 µg/kg). In a quantitative study in the Powell River, Ahlstedt and Tuberville (1997) attributed a 15-year decline of the oyster mussel, Cumberlandian combshell, and rough rabbitsfoot and the long-term decrease in species diversity (from 30 in 1979 to 21 in 1994) to general stream degradation due primarily to coal mining activities in the headwaters. Mining activities also likely contributed to the extirpation of the purple bean from the Powell River several decades ago. Iron and phosphate mining in the Duck River watershed was thought to have caused mussel declines in the early 1900s (Ortmann 1924a).

Stressor: Gravel-mining
Exposure:
Response:
Consequence:
Narrative: In-stream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, Yokley and Gooch 1976, Grace and Buchanan 1981, Hartfield and Ebert 1986, Schuster et al. 1989, Hartfield 1993, Howard 1997). Lagasse et al. (1980), Kanehl and Lyons (1992), and Roell (1999) reviewed the physical and biological effects of mining sediment from streams. Negative impacts include riparian forest clearing (e.g., mine site establishment, access roads, lowered floodplain water table); stream channel modifications (e.g., geomorphic instability, altered habitat, disrupted flow patterns [including lowered elevation of stream flow], sediment transport); water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature); macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation); and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions). Once mussels have been eliminated, a decade or more may pass before recolonization occurs (Stansbery 1970, Grace and Buchanan 1981). Substrate disturbance and sedimentation impacts can also be realized for considerable distances downstream (Stansbery 1970), and possibly upstream (Hartfield 1993). Mining activities on the Elk River (Ahlstedt 1991b) may have played a role in the extirpation of the oyster mussel and Cumberlandian combshell from that river. Gravel removal was apparent at 12 sites along a 40-mile stretch of the lower Elk River during 1999 mussel sampling (Anonymous 1999). Activities that occur without a permit, unless controlled, may prevent the long-term reintroduction of some of the 13 federally listed mussels that are known from the Elk.

Stressor: Pollution
Exposure:
Response:
Consequence:
Narrative: Contaminants contained in point and nonpoint discharges can degrade water and substrate quality and adversely impact, if not destroy, mussel populations (Horne and McIntosh 1979, Neves and Zale 1982, McCann and Neves 1992, Havlik and Marking 1987). Although chemical spills and other point sources (e.g., ditch, swale, artificial channel, drainage pipe) of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result, in part, from the subtle, pervasive effects of chronic low-level contamination (Naimo 1995). The effects of excessive concentrations of heavy metals and other contaminants on freshwater mussels were studied by Mellinger (1972), Fuller (1974), Havlik and Marking (1987), Naimo (1995), Keller and Lydy (1997), and Neves et al. (1997). Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also negatively affect biological processes (Jacobson et al. 1993, Naimo 1995,

Keller and Zam 1991, Keller and Lydy 1997). In laboratory experiments, mussels suffered mortality when exposed to 2.0 parts per million (ppm) cadmium, 12.4 ppm chromium, 19.0 ppm copper, and 66.0 ppm zinc (Mellinger 1972, Havlik and Marking 1987). Most metals are persistent in the environment (Miettinen 1977), remaining available for uptake, transportation, and transformation by organisms for long periods (Hoover 1978). Highly acidic pollutants such as metals are capable of contributing to mortality by dissolving mussel shells (Stansbery 1995). Among other pollutants, ammonia has been shown to be lethal to mussels at concentrations of 5.0 ppm (Havlik and Marking 1987). Ammonia is oftentimes associated with animal feedlots, nitrogenous fertilizers, and the effluents of older municipal wastewater treatment plants (Goudreau et al. 1993). This contaminant may become more problematic for juvenile mussels during periods of low flow, when water temperatures increase (Newton et al. 2003b). In stream systems, ammonia is most prevalent at the substrate/water interface (Frazier et al. 1996). Due to its high level of toxicity and the fact that the highest concentrations occur in the microhabitat, where mussels live, ammonia should be considered among the factors potentially limiting the survival and recovery of mussels at some locations (Augspurger et al., in press). Certain adult species may tolerate short-term exposure (Keller 1993). However, the effects of heavy metals and other toxicants are especially profound on juvenile mussels (Robison et al. 1996) and on the glochidia, which appear to be very sensitive to toxicants such as ammonia (Goudreau et al. 1993). Low levels of some metals may inhibit glochidial attachment (Huebner and Pynnönen 1992). Juvenile mussels may inadvertently ingest contaminated silt particles while feeding. Mussel recruitment may therefore be reduced in habitats with low but chronic heavy metal and other toxicant inputs (Yeager et al. 1994, Naimo 1995, Ahlstedt and Tuberville 1997), which may have contributed to the demise of these five species. Common contaminants associated with households and urban areas, particularly those from industrial and municipal effluents, may include heavy metals, ammonia, chlorine, phosphorus, and numerous organic compounds. Nonpoint-source runoff from urban areas tends to have the highest levels of many pollutants, such as phosphorus and ammonia, when compared to other catchments (Mueller et al. 1995). Wastewater is discharged at sites throughout the country with permits (and some without permits) issued by the National Pollution Discharge Elimination System (NPDES). Elimination sites are ubiquitous in watersheds containing rough rabbitsfoot populations, providing ample opportunities for some pollutants to enter streams. Collectively, pollutants from these sources may cause decreased dissolved oxygen levels, increased acidity, and other water chemistry changes that may be lethal to mussels (Horne and McIntosh 1979, Rand and Petrocelli 1985, Sheehan et al. 1989, Keller and Zam 1991, Dimock and Wright 1993, Goudreau et al. 1993, Jacobson et al. 1993, Keller 1993). Sediment from the upper Clinch River, where several of these species occur, was found to be toxic to juvenile mussels (Robison et al. 1996). Ahlstedt and Tuberville (1997) speculated that the presence of toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream. Wilcove and Bean (1994) reported that studies indicated that mussel reproduction below the site of the Appalachian Power Company's (APCO) electric generating station in Carbo, Virginia, was being inhibited by copper discharges. In addition, copper was shown to be toxic to mussels at levels below the U.S. Environmental Protection Agency (EPA) criteria established in Virginia. The Virginia State Water Control Board began proceedings to impose a special water quality standard for copper below the plant. In 1992, the State and APCO agreed on a lower standard for copper for this specific stretch of the Clinch. APCO is spending several million dollars to control copper discharge from its facility to meet the new standard (Wilcove and Bean 1994). Although the Clean Water Act (CWA), administered by the EPA, has helped eliminate many point-source effluents, "straight pipes" (pipelines conveying untreated household effluents; e.g., chlorine, detergents, household chemicals, human waste, etc., from rural homes directly into streams) continue to discharge wastes. Fraley and Ahlstedt (2000) thought that effluents from straight pipes were partially to blame for the documented decline of the native mussel fauna in Copper Creek from 19 species in 1980 to 11 species in 1998. Included in the historical Copper Creek fauna were the oyster mussel, rough rabbitsfoot, and purple bean, although only the latter species was found live in 1998. Numerous other streams in the Cumberlandian Region doubtless also have straight pipes discharging pollutants into mussel habitat. Agricultural sources of chemical contaminants are considerable and include two broad categories--nutrients and pesticides (Frick et al. 1998). Nutrient enrichment generally occurs as a result of runoff from livestock farms and feedlots and from fertilizers used on row crops. Various OWCs may also be associated with livestock concentrations (Kolpin et al. 2002). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated, resulting in overenrichment, a condition exacerbated by low-flow conditions. Excessive stands of filamentous algae, a common manifestation of overenrichment, alter the surface of the stream bottom and may represent a shift in algal communities that could disrupt, particularly, juvenile mussel food supplies. Juvenile mussels, utilizing interstitial habitats, are particularly affected by excessive levels of algae-consuming dissolved oxygen during nocturnal respiration (Sparks and Strayer 1998). Increased risks from bacterial and protozoan infections to eggs and glochidia may also pose a threat (Fuller 1974). Hoos et al. (2000) summarized data on nutrient loading in the lower Tennessee River system, where overenrichment was the cause of impairment in 37 stream segments. Nonpoint sources, primarily agricultural inputs, accounted for the largest percentage of total nitrogen and total phosphorus in all streams tested in the study area. Relatively high levels of nutrients were prevalent in the Duck River, where a large population of the oyster mussel occurs. Nutrient levels were also analyzed in the upper Tennessee River system by Hampson et al. (2000). Overall, nutrient concentrations were generally lower than national concentrations and were relatively high only on a localized scale. Secondly, pesticides, primarily from row crops, are a major s

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Sedimentation is widely thought to have contributed to the decline of mussel populations (Kunz 1898; Ellis 1931, 1936; Cordone and Kelly 1961; Imlay 1972; Coon et al. 1977; Marking and Bills 1979; Wilber 1983; Dennis 1985; Schuster et al. 1989; Wolcott and Neves 1990; Houp 1993; Richter et al. 1997, Brim Box 1999; Henley et al. 2000; Fraley and Ahlstedt 2000). Specific biological impacts on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity, and physical smothering (Ellis 1936, Stansbery 1971, Markings and Bills 1979, Kat 1982, Vannote and Minshall 1982, Aldridge et al. 1987, Waters 1995). Brim Box (1999) showed that burying adult mussels under 5.5 inches of sediment in the Apalachicola, Chattahoochee, and Flint River basin significantly decreased their chances of surviving. Intuitively, much thinner layers of sediment may result in juvenile mortality. Some studies tend to indicate that the primary impacts of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999). The physical effects of sediment on mussels appear to be multifold (Brim Box and Mossa 1999). They are potentially impacted by changes in suspended and bed material load; bed sediment

composition associated with increased sediment production and runoff in the watershed; channel changes in form, position, and degree of stability; changes in depth or the width/depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave them high and dry (Vannote and Minshall 1982, Kanehl and Lyons 1992, Hartfield 1993, Brim Box and Mossa 1999; see earlier discussion on “Gravel Mining”). Interstitial spaces in mixed substrates may become clogged with sediment (Gordon et al. 1992). When clogged, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999), thus reducing habitat for juvenile mussels and some adults as well. Salomons et al. (1987) and the National Research Council (1992) indicated that sediment may act as a vector for delivering contaminants such as nutrients and pesticides to streams. Juveniles can readily ingest contaminants adsorbed to silt particles during normal feeding activities (see “Food Habits”). These factors may help explain, in part, why so many mussel populations appear to be experiencing recruitment failure. Host fish/mussel interactions may be indirectly impacted by changes in stream sediment regimes through three mechanisms (Brim Box and Mossa 1999). First, fish abundance (Berkman and Rabeni 1987), diversity (Waters 1995), and reproduction (Muncy et al. 1979) may be reduced with increased sedimentation. Second, excessive sedimentation likely impedes host fish attractant mechanisms (e.g., mantle flaps, conglutinates, superconglutinates that mimic fish prey item) (Haag et al. 1995, Burkhead et al. 1997). Third, sedimentation on shoal substrates may interfere with the ability of some species’ adhesive conglutinates to adhere to rock particles (Hartfield and Hartfield 1996). Many Southeastern streams have increased turbidity levels due to siltation (van der Schalie 1938). Some of these five species attract host fishes with visual cues, luring fish into perceiving that their glochidia are prey items (see “Reproductive Biology of the Five Species”). Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991) and may have contributed to population declines in some of these mussel species. In addition, mussels may be indirectly affected when turbidity levels significantly reduce the amount of light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992). Agricultural activities produce the most significant amount of sediment that enters streams (Waters 1995). Neves et al. (1997) stated that agriculture (including both sediment and chemical runoff) affects 72 percent of the impaired river miles in the country. Unfortunately, the CWA does not regulate agricultural runoff, return waters, or discharge flows (D. Powell, EPA, letter dated June 20, 2003). Armour et al. (1991) reviewed the effects of livestock grazing on riparian and stream ecosystems. Unrestricted access by livestock is a significant threat to streams (Trimble and Mendel 1995) and their mussel populations throughout much of the Cumberlandian Region (Anonymous 1999, Fraley and Ahlstedt 2000). Grazing may reduce infiltration rates and increase runoff and erosion (Brim Box and Mossa 1999). Trampling causes or accelerates stream-bank erosion, and grazing reduces a bank’s resistance to erosion (Armour et al. 1991, Trimble and Mendel 1995). In addition, livestock may add nutrients to streams at levels that are not easily assimilated, particularly during low-flow conditions, resulting in overenrichment. Fraley and Ahlstedt (2000) attributed the decline of the Copper Creek mussel fauna between 1980 and 1998, among other factors, to an increase in cattle grazing and loss of riparian vegetation in the stream. They considered the oyster mussel and rough rabbitsfoot as possibly being extirpated from Copper Creek. Erosion from silvicultural activities accounts for 6 percent of the nation’s sediment pollution (Henley et al. 2000). Sedimentation impacts are more the result of logging roads than the actual harvesting of timber (Waters 1995, Brim Box and Mossa 1999).

Stressor: Urbanization
Exposure:
Response:
Consequence:
Narrative: Developmental activities associated with urbanization (e.g., highways, building construction, infrastructure creation, recreational facilities) may contribute significant amounts of sediment and other pollutants in quantities that may be detrimental to stream habitats (Waters 1995, Couch and Hamilton 2002). Urban development changes sediment regimes by creating impervious surfaces and drainage system installations (Brim Box and Mossa 1999). The highest erosion rates are generally associated with construction activities, which can contribute sediment at a rate 300 times greater than from forested land (USDA 1977). Stream channel erosion contributes up to two-thirds of the total sediment yield in urbanized watersheds (Trimble 1997). With development, watersheds become more impervious, resulting in increased storm-water runoff into streams (Myers-Kinzie et al. 2002) and a doubling in annual flow rates in completely urbanized streams (DeWalle et al. 2000). Impervious surfaces may reduce sediment input into streams but result in channel instability by accelerating storm-water runoff, which increases bank erosion and bed scouring (Brim Box and Mossa 1999). Stream channels become highly unstable as they respond to increased flows by incising, which increases shear stress and bed mobilization (Doyle et al. 2000). With increasing shear stress, benthic organisms become increasingly dislodged downstream (Myers-Kinzie et al. 2002). Studies have indicated that high shear stress is associated with low mussel densities (Layzer and Madison 1995) and that peak flows and substrate movement limits mussel communities, particularly at the juvenile stage (Myers-Kinzie et al. 2002). For some of these species, a considerable amount of habitat has been lost, particularly in metropolitan areas in Tennessee (e.g., Knoxville, Nashville, Chattanooga). Streams that contain these five species, and which are currently threatened with development activities, include Sinking Creek (potential interstate highway, industrial park; Cumberland elktoe) and Buck Creek (potential interstate highway, Cumberlandian combshell), Kentucky; Bear Creek, (instream gold mining, Cumberlandian combshell), Alabama and Mississippi; and the Duck River (general development from rapid growth, oyster mussel) Tennessee (Butler, pers. obs., 2002; Cicerello, pers. comm., 2003; L. Colley, TNC, pers. comm., 2002). Water withdrawals for agricultural irrigation and municipal and industrial water supplies are an increasing concern for all aquatic resources and are directly correlated with expanding human populations. This impact has the potential to be a particular problem for the Cumberland elktoe population in the Big South Fork system and the oyster mussel population in the Duck River. Droughts may also be a threat to these species, particularly populations occurring in smaller streams. Impacts include decreased flow velocities and depressed dissolved oxygen levels (Johnson et al. 2001). Stochastic events, such as droughts, may be exacerbated by global warming and water withdrawals. These anthropogenic activities act insidiously to lower water tables, thus making mussel populations susceptible to depressed stream levels.

Stressor: Invasive species
Exposure:
Response:
Consequence:
Narrative: The asian clam has been implicated as a competitor with native mussels for resources such as food, nutrients, and space (Heard 1977, Kraemer 1979, Clarke 1986), particularly as juveniles (Neves and Widlak 1987). According to Strayer (1999b), dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed

juveniles. Periodic dieoffs may produce enough ammonia and consume enough oxygen to kill native mussels (Strayer 1999b). The invasion of the nonnative zebra mussel (Dreissena polymorpha [Pallas, 1773]) poses a threat to the mussel fauna of the Cumberlandian Region (Ricciardi et al. 1998). Zebra mussels in the Great Lakes have attached, in large numbers (up to 10,000 per unionid), to the shells of live and fresh dead native mussels (Schlosser and Kovalak 1991), and they have been implicated in the loss of mussel beds (Hunter and Bailey 1992, Masteller et al. 1993, Schlosser and Nalepa 1995). Although zebra mussels are now in the Tennessee and Cumberland River systems, the extent to which they will impact native mussels is unknown.

Recovery

Reclassification Criteria:
Downlisting from endangered to threatened status will occur when the following criteria are met for the protection of extant stream populations, discovery of currently unknown stream populations, and/or reestablishment of historical stream populations: (1) three streams with distinct viable populations of the rough rabbitsfoot have been established; (2) one distinct naturally reproduced year class exists within each of the viable populations; (3) research studies of the mussels' biological and ecological requirements have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring; (4) no foreseeable threats exist that would likely impact the survival of the species over a significant portion of their ranges; (5) within larger streams the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable; and (6) biennial monitoring of the five species yields the results outlined in criterion (1) above over a 10-year period.

Delisting Criteria:
Delisting will occur when the following criteria are met for protecting extant stream populations and reestablishing viable stream populations: (1) four streams with distinct viable populations of the rough rabbitsfoot have been established; (2) two distinct naturally reproduced year classes exist within each of the viable populations; (3) research studies pertaining to the mussels' biological and ecological requirements have been completed and recovery measures developed and implemented from these studies have been successful as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited in each of the viable populations as determined through biennial monitoring; (4) no foreseeable threats exist that would likely threaten the survival of any of the viable populations; (5) within larger streams the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable; and (6) biennial monitoring of the five species yields the results outlined in criterion (1) above over a 10-year period.

Recovery Actions:

- 1. Utilize existing legislation/regulations to protect current and newly discovered populations.

- 2. Determine the species' life history requirements and threats and reduce or alleviate those threats which threaten the species.
- 3. Develop and use an information/education program to solicit the assistance of local landowners, communities, and others to recover the species.
- 4. Search for additional populations, and through propagation activities, pursue augmentations or reintroductions in order to establish viable populations.
- 5. Conduct anatomical and molecular genetic analysis of the species to determine the potential occurrence of species complexes or hidden biodiversity.
- 6. Develop and implement a monitoring program, and annually assess the recovery program where needed.

References

Recovery Plan

Final Rule for critical habitat

Nature Serve

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered Mussels in the Tennessee and Cumberland River Basins. Final rule. 69 FR 53136 - 53180 (August 31, 2004).

SPECIES ACCOUNT: *Quadrula fragosa* (Winged Mapleleaf)

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 6/20/1991, 06/14/2001; Great Lakes-Big Rivers Region (R3), Southeast Region (R4) (USFWS, 2016)

Physical Description

A freshwater mussel. The shell has two prominent, heavily tuberculated, radial ridges (Conrad 1835, Utterback 1915). The posterior slope is slightly concave with a few narrow, costate tubercles, which are more prominent near the margin (Conrad 1835, Utterback 1915, Watters 1988). The lateral slope is marked posteriorly by a wide radial sulcus, bordered by a row oferect, prominent tubercles, which extend from the umbos to the margin. Minor tubercles are scattered among the major ones, particularly in the anterior series (Scammon 1906). The ligament slope is straight or slightly oblique (Conrad 1835, Utterback 1915). Growth lines are continuous and prominent (Scammon 1906). The posterior margin is direct and slightly emarginate (Conrad 1835), forming a right angle with the posterior half of the ventral margin (Scammon 1906). The ventral margin is rounded and forms a full curve with the anterior margin (Scammon 1906, Simpson 1914). The dorsal margin is straight or only slightly curved and is oblique to both the anterior and posterior margins (Scanimon 1906). The light brown ligament is short and ofmoderate thickness (Scammon 1906). The epidermis of adults is dull brown, usually with two or three broad and widely interrupted green rays (Conrad 1835, Simpson 1914, Ortmann 1924). Some describe the adult color as “horn color to seal-brown” (Scammon 1906) or even dark yellowish (Utterback 1915). Juveniles are tan to greenish (Watters 1988).

Taxonomy

Quadrulafragosa shows closest conchological affinity to Q. quadrula (= Q. lachrymosa, Obliquaria quadrula, Unio rugosus, U lachrymosus, U quadrulus) and is therefore most likely to be confused with this species throughout most ofthe Mississippi River drainage. The shell profile ofQ. fragosa is more roundly-quadrate (Conrad 1835, Call 1900, Simpson 1914, Wilson and Clarke 1914, Utterback 1915, Coker 1921, Ortmann 1924, Baker 1928) than that ofQ. quadrula, which is transversely quadrate. The postero-dorsal slope ofQ. fragosa is wider and more alate (Baker 1928; Watters 1988; M.E. Gordon, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, in lilt. 1992). The shell of Q. fragosa is more inflated (Conrad 1835, Call 1900, Wilson and Clarke 1914, Baker 1928) and more strongly tuberculated (Conrad 1835, Call 1900, Ortmann 1924, Baker 1928, Watters 1988) than Q. quadrula, and on the posterior slope of Q. fragosa the tubercles are arranged in transverse rows which form thick, relatively smooth, and well-separated costae (Scammon 1906, Wilson and Clarke 1914, and Gordon 1992).

Historical Range

Museum records indicate that it was distributed throughout a considerable portion of the Interior Basin: Ohio and Sciota rivers (Ohio), Wabash and White rivers (Indiana), Sangamon River (Illinois), Tennessee and Duck rivers (Tennessee), St. Croix and Wisconsin rivers (Wisconsin), Cedar, Iowa, Mississippi, and Racoon rivers (Iowa), Little Fox River (Missouri), and Fall and Neosho rivers (Kansas). Records from the Kiamichi River, Oklahoma, were previously considered uncertain (USFWS, 1997) but recently Hove et al. (2003) confirmed its presence there.

Current Range

The 1997 Recovery Plan stated that Quadrula fragosa is probably extirpated from its entire historic range except for one remnant population in the St. Croix River between Minnesota and Wisconsin and the Ouachita River in Arkansas. Since then, this species has been found in the Ouachita River and Saline River, Arkansas; in the Bourbeuse River, Missouri; and, in the Little River, Oklahoma and Arkansas. (USFWS, 2015).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Reproduction in unionid mussels occurs during a discrete breeding season. This season is not known for Q. fragosa, although the presumed brooding period is late May to the middle ofJuly (Baker 1928, Heath and Rasmussen 1990). Wilson and Clark (1914) reported two gravid Q. fragosa from the Cumberland River on May 17 and 29, and noted they brood glochidia on all four gills. Sexes in unionid mussels are normally separate, and females produce a large number ofeggs (500,000 to several million), which are brooded on specialized marsupia on the gills (Oesch 1984). Sperm are shed into the water in “volvocoid bodies” and taken into the female through the incurrent siphon (Fuller 1974). After fertilization, zygotes develop into larval glochidia, which are typically either spined or hooked, depending on the subfamily (Fuller 1974). Glochidia are released into the water through the excurrent siphon and passively infect a vertebrate host, typically a fish (Oesch 1984). Glochidia attach and then encyst on either a host fish gill or fin (Oesch 1984). Parasitism is normally obligate, but the specificity ofthe hostparasite relationship is highly variable and poorly known for most species (Fuller 1974). Unionids may utilize only one host species or many species across a broad range oftaxonomic groups. Knowledge of host species is very limited because of problems in identifying glochidia andbecause ofvariability within individual species; a mussel may parasitize one species in one part of its distribution and a different species in a different part ofits range (Heath 1991). Oesch (1984), however, believes the distribution ofa host fish can limit the distribution of a mussel. After encystment, glochidia metamorphose and drop offoftheir host. They must settle in suitablehabitat because their mobility is limited (Oesch 1984). The maximum age of Q. fragosa is not known, but the oldest known individual in the St. Croix population was aged at 22 years. Fish hosts for glochidia: The host fish for Q. fragosa glochidia is unknown. However, something is known offish hosts for six other Quadrula species (Oesch 1984, Hill 1986). Historical studies offish hosts should be treated with caution, however, because they were premised on the highly problematic assumption that glochidia could be identified to species (Hoggarth 1992). Sixteen fish species from 5 families are thought to be hosts to glochidia of the genus Quadrula and 11 of these are found in the St. Croix River. Of these 11 fish species, 8 are known from recent surveys ofthe stretch ofriver where Q.fragosa is found. These include bluegill (Lepomis machrochirus), black crappie (Pomoxis nigromaculatus), white crappie (P. annularis), channel catfish (Ictaluruspunctatus), largemouth bass (Micropterus salmoides), and the spotfin shiner (Notropis spilopterus). The brown bullhead (I. nebulosus) has not been found in the St. Croix River since 1975 and the flathead catfish (Pylodictis olivaris) has demonstrated a historical decline in the St. Croix (Fago 1986). This might be significant because this catfish serves as host to three Quadrula species. Only one fish host is known for Q. quadrula (flathead catfish), while the other Quadrula are thought to use between two and six fish hosts from different taxonomic families. The members of the genus also share fish hosts, e.g., three Quadrula species use flathead catfish, while two use bluegill, channel catfish, and white crappie. Our understanding of the breeding behavior of Q. fragosa has improved substantially since the species was listed in 1991and even since the recovery plan was approved in 1997. At that time, Q. fragosa was assumed to behave in a manner typical of members of the subfamily, Ambleminae - i.e., to brood its young and to infest its host in the summer (U.S. Fish and Wildlife Service 1997, p. 5). To confirm the brooding period, Heath et al. (2000, p. 2) collected and inspected Q. fragosa about once every two weeks in 1999 from early April until late October in the St. Croix River. They inspected any Q. fragosa that they found by "gently prying apart the two valves" and visually inspecting for inflated gills (Heath et al. 2000, p. 3). They found no evidence of brooding until 31 August and none after 6 October, confirming Q. fragosa as a fall short-term (tachytictic) brooder. The appearance and behavior of brooding Q. fragosa changes markedly when they are ready to infest their host. For a few days during its approximately six- week brooding period the posterior mantle around the excurrent aperture of brooding Q. fragosa becomes "greatly expanded" with swelling and development of "black-ridged crenulations overlaying the gray mantle" (Heath et al. 2000, p. 5; Figure 1, Hove et al. 2000, p. 3; Fig. 1, Barnhart et al. 2008, p. 376-378; Hove et al. 2012). Q. fragosa brood glochidia in this "mantle magazine", gape widely, and are "reluctant to close the shell when touched" (Barnhart 2009, p. 6). When in this condition, movement of water into and out of the incurrent and excurrent siphon, respectively, appears to cease due to blockage of the excurrent aperture, as an adaptation to avoid flushing glochidia from the magazine, or both (Barnhart 2009, p. 6-7). The prominent gape and emersion of the mussel from the substrate may also be mechanism for maintaining the ventilation of the ctenidia (gills) while siphoning is ceased (Barnhart 2009, p. 7). The prominent display developed by brooding Q. fragosa allows host fish to trigger rapid release of glochidia, although spontaneous release of glochidia and conglutinates may also occur on occasion as an alternative strategy (Barnhart 2009, p. 7; Sietman et al. 2012, p. 44). As is typical with species that use catfish as hosts, Q. fragosa emerges from the substrate when brooding glochidia; during the brooding period a greater proportion of Q. fragosa are exposed at the surface than outside the brooding period (Hove et al. 2000, p. 3; Sietman et al. 2012, p. 43). There are no obvious differences in appearance of brooding Q. fragosa between night and day (Hove et al. 2000, p. 3) (USFWS, 2015).

Geographic or Habitat Restraints or Barriers

Larvae: impoundments

Juvenile: impoundments

Adult: impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Very little is known about the specific habitat requirements ofQ. fragosa. Historical descriptions characterized Q. fragosa as a “large-stream” species (Wilson and Clark 1914, Baker 1928) found on mud (Baker 1928), mud-covered gravel (Ortmann 1924), and gravel (Ortmann 5 1925) substrates. There are three historical reports of Q.fragosa from impoundments (Wilson and Clark 1914, Scruggs 1960 [but note the qualification ofthis record in the historical distribution section]; and University of Wisconsin Zoology Museum 1985 collection from Lake St. Croix). Wilson and Clark (1914) reported Q. fragosa from 21 different beds in the Cumberland

River system and these beds varied considerably in their habitat from impounded water to fast flowing water and from muddy to sandy to clear gravel substrates. They found mussels in 1.5 m to 6.5 m depth. Ortmann (1924) reported Q. fragosa from a spillwayjust below a dam. There is substantial information on the habitat ofthe remnant population in the St. Croix River. Heath (1995) found Q. fragosa in riffles with clean gravel, sand, or rubble substrates and in clear water ofhigh water quality. Quadrulafragosa was most abundant in shallow areas with fast current. The species was absent from recent surveys ofLake St. Croix (Heath and Rasmussen 1990, Fuller 1980a, Havlik 1985, Doolittle 1988), a natural impoundment and part ofthe historic distribution of Q.fragosa (Fuller 1980c, Malacological Consultants 1985 and 1986, Havlik 1987, Doolittle 1988). Lake St. Croix has a fine-sand or silt substrate and more turbid water than upstream reaches where Q. fragosa occurs. The following is the St. Croix River habitat ofQ. fragosa; the St. Croix River may not reflect ideal Q. fragosa habitat. The St. Croix River became part of the National Wild and Scenic Riverway system in 1968. Graczyk (1986) provides a thorough description ofthe basin anddiscussion ofwater quality of streams in the basin. The St. Croix flows south from Upper St. Croix Lake in northwestern Wisconsin to the Mississippi River at Prescott, Wisconsin/Hastings, Minnesota. The river's drainage area is 22,225 km2 (Graczyk 1986). Forest products, agriculture, and recreation are major land uses in the basin (Graczyk 1986). The climate is continental, with long, cold winters and relatively short summers. Average annual temperature at Spooner, Wisconsin, is 5.60C, ranging from a mean of-11.80C in January to a mean of2l.90C in July. Normal annual total precipitation at Spooner is 73.4 cm varying from 11.3 cm in June to 1.7 cm in January and February. Mean annual snowfall is about 115 cm (Graczyk 1986).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Declined 70 to 90 percent

Number of Populations:

1 to 5

Population Size:

50 - 1000 individuals

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

The principal reasons given in the final rule (USFWS 1991) for listing Q.fragosa as endangered are: 1) This species has been eliminated from nearly all of its original 11-state range (Figure 2) and is now known from a single extant population along one 20-kilometer reach ofthe St. Croix River. 2) The remnant population is thought to be small and therefore vulnerable to stochastic disturbances, such as toxic substance spills or low water levels. 3) Reproductive success is also jeopardized by the small population size. Surveys in 1988 and 1989 (Heath and Rasmussen 1990) failed to collect any individuals brooding young or less than four years old, even though congeneric individuals collected in the same survey showed evidence of successful reproduction. Additionally, small populations are known to be vulnerable to various genetic constraints which can independently threaten a species (Allendorfand Leary 1986). 4) Changes in land use practices in the watershed are anticipated because the watershed is close toa major and growing metropolitan area. These changes will probably affect the habitat quality of Q. fragosa. Also, recreational boat use in the vicinity of the population is heavy and potentially damaging.

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative:

Stressor: Small, isolated populations
Exposure:
Response:
Consequence:
Narrative:

Stressor: Pollution
Exposure:
Response:
Consequence:
Narrative:

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative:

Stressor: stochastic disturbances (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Although several populations of Q. fragosa are considered stable or increasing (Table 4), the range and abundance of remnant populations continue to remain small and vulnerable to stochastic disturbances. For example: • In the Saline River, changes in species composition/abundances at the mussel beds has been observed indicating a potential shift toward more sandy habitats, which may result in future concerns for Q. fragosa. This shift is

suspected to be driven by land use changes and could result in changes to long term abundance and resiliency in that watershed. • In the Little River, Q. fragosa populations have also shifted, and there have been some mussel die-off related to drought and potential issues with water fluctuations below the Broken Bow Hydroelectric Dam. • Increasing levels of fine sediments and fluctuating flow (including drought) continues to potentially threaten Q. fragosa populations in the St. Croix River. Q. fragosa continues to be exceedingly rare compared to more common species, making it difficult to assess the impacts of some of the threats. More population level survey and trend data are needed to fully assess population condition, ongoing recovery actions, and risk from threats across its range. The National Council for Air and Stream Improvement, Inc. (NCASI) submitted information during the public comment period about the conservation benefits of forest management Best Management Practices (BMPs) on managing threats to aquatic species, including Q. fragosa. In their comments, the NCASI provided a detailed literature review of the best available scientific and commercial data available to describe how: • Best management practices are effective for protecting water quality and habitat for atrisk species (Ice et al. 1997, Ice and Schoenholtz 2003, Aust and Blinn 2004, Ice 2004, Ice and Stednick 2004, Shepard et al. 2004, NCASI 2009, Anderson and Lockaby 2011, NCASI 2012, Cristan et al. 2016). Best management practices are effective for protecting aquatic biota (Adams et al. 1995, Kedzierski and Smock 2001, Vowell 2001, Williams et al. 2002, Carroll et al. 2004, Vowell and Frydenborg 2004, Grippo and McCord 2006, Griswold et al. 2006, McCord et al. 2007, Wilder and Augustin 2008, DaSilva et al. 2013) (USFWS, 2024).

Recovery

Reclassification Criteria:
a) Three discrete populations in at least two tributaries ofthe Mississippi River drainage basin. For the purposes ofthis plan, two beds ofmussels maybe considered discrete populations if they are sufficiently geographically isolated from each other so both are unlikely to be affected by a single stochastic event, such as a toxic spill or a disease outbreak. b) All three populations must be viable as defined in the narrative outline ofthis document under Task SA. c) All three populations must have demonstrated persistence as defined in the narrative outline ofthis document under Task SB. d) All three populations must have long-term habitat protection as defined in the narrative outline ofthis document under Task SC.

Recovery Priority Number: 2C

Delisting Criteria:
a) Five discrete populations in at least three tributaries ofthe Mississippi River drainage basin unless Task 2D4 indicates more populations or tributaries are required. For purposes ofthis plan, two beds of mussels may be considered discrete populations if they are sufficiently geographically isolated from each other that both are unlikely to be affected by a single stochastic event, such as a toxic spill or a disease outbreak. b) All five populations are viable as defined in the narrative outline ofthis document under Task 5A. c) All five populations must have demonstrated persistence as defined in the narrative outline of this document under Task SB. d) All five populations must have long-term habitat protection as defined in the narrative outline ofthis document under Task SC.

Recovery Actions:

- Recovery Priority Number: 2C. Task 1. Preserve the St. Croix population of Q. fragosa: All known locations of Q. fragosa lie in the St. Croix National Scenic Riverway, administered by the National Park Service. The National Park Service is therefore responsible for developing and coordinating all aspects of Task 1. Task lA, Population status: **Task lAl, Community population monitoring: Set up permanent monitoring plots to monitor the abundance and age structure of members of the unionid community within the known geographic range of Q. fragosa. Task iB, Stream flow: The following are recommended to address the central issue of assuring adequate stream flow for Q. fragosa in the St. Croix: **Task iBi, Flow gauge: Establish and maintain a flow gauge at Folsom Island through the completion of the instream flow study. **Task 1B2, Instream flow study: Conduct an instream flow study to determine the relationship between discharge rates at the dam and water levels at critical spots downstream of the dam. The study report should include a discussion of habitat availability at each of the studied flow rates. Task 1B3, Hourly flow records: Analyze and describe the USGS hourly flow records (mean, maximum, and minimum) for the past 20 years to describe the flow regime the mussels were exposed to in the past. The report should include discussion of any significant correlations between stream flow and reproduction. **Task 1B4, NSP: Negotiate with Northern States Power to implement a flow regime indicated by the above studies to protect Q. fragosa habitat. Task iC, Toxic spills: The following information should be gathered to assess the threat of toxic material to Q. fragosa: Task iCi, Federal/State/Local Emergency Response Plans: Prepare a review report on USEPA; MPCA; WDNIR Wisconsin Department of Agriculture (WDA); Wisconsin Department of Military Affairs, Division of Emergency Government: and Local Emergency Planning Committee (LEPC) response plans for the St. Croix River. The report should address adequacy of the plans (on site materials, time to implement) to deal effectively with potential spills identified in Tasks 1C2 and 1C3. Task 1C2, Harmful material transport: Produce a report that inventories and quantifies the nature of harmful material transport on or across the river upstream from Stillwater by watercraft, pipeline, truck, and rail. This report should be used in developing Federal, state, and local Emergency Response Plans. **Task 1C3, Harmful material storage: Produce a report that inventories and quantifies the location and nature of harmful material storage in the St. Croix watershed upstream of Stillwater, Minnesota. The report should be used in developing or revising Federal, state, and local Emergency Response Plans. Task 1C4, Emergency response planning: Develop a St. Croix River Emergency Response Plan, if one is not currently in place through Task 1 Cl. This plan should explicitly address all harmful material threats identified in Tasks 1 C2 and 1 C3. This plan should also include a protocol for state and Federal natural resource agencies (MDNR, MPCA, USNPS, WDNR, WDA, and USFWS) to coordinate with emergency response agencies to protect Q. fragosa in the event oaf spill. This planning effort should be incorporated into Federal, state, and local Emergency Response Plans. Task 1C5, NSP: Arrange with Northern States Power to manage its St. Croix Falls dam's flow release in the event oaf spill above the dam. Coordinate this Task with 1C4. Task 1C6, Hazardous waste facilities: Request that an Environmental Impact Statement (EIS) be required for any proposed hazardous waste facility, such as the proposed hazardous waste disposal facility at Osceola, and that any EIS prepared must specifically address the potential impact on Q. fragosa. Task iD, Exotic mussels: The following actions are recommended to address the issue of zebra mussels (D. polymorpha): **Task iDi, Monitoring: Continue annual monitoring for zebra and quagga mussels, initiated in summer 1992, in the St. Croix River. **Task 1D2, Zebra mussel loads: As part of mussel community monitoring (Task lAl), monitor zebra mussel loads on mussels within the known Q. fragosa range. * *Task 1D3, Assess impact:

Prepare a report assessing the likely effects of zebra mussels on Q. fragosa. **Task 1D4, Emergency response plan: Develop and implement a zebra mussel emergency response plan in cooperation with the Department of the Interior (USNPS and USFWS). **Task 1D5, Protective legislation: Develop state and Federal legislation to prevent or retard the spread of exotic species in the St. Croix River. Task lE, Habitat degradation: The following actions are recommended to address the issue of habitat degradation: Task tEl, Federal agencies: Establish formal agreements between the Service, National Park Service, and USACOE to the effect that National Park Service and USACOE notify the Service in the event of any development or maintenance work that could disturb or endanger the Q. fragosa population or its habitat. Task 1E2, State agencies: Establish formal agreements with Minnesota and Wisconsin Departments of Transportation and Departments of Natural Resources to the effect that they will notify the Service prior to their development or maintenance work that could disturb or endanger the Q. fragosa population or its habitat. Task 1E3, County zoning: Review county zoning rules for St. Croix and Polk Counties, Wisconsin, and Washington and Chisago Counties, Minnesota. The report should include a description of how zoning rules are likely to adversely impact or protect water quality in the drainage basin. **Task 1E4, Critical habitat: Prepare a proposed rule to designate appropriate areas in the St. Croix River, such as the east channel of Folsom Island, as critical habitat under the Act. Task 1E5, Natural heritage databases: Complete entry of Q. fragosa distributional data into Minnesota and Wisconsin Natural Heritage databases; make the data available to USFWS, USNPS, USACQE, MDOT, MPCA, WDOT, and local county zoning boards. Task iF, Human disturbance and destruction of Q. fragosa: The following actions are recommended to address the issue of human disturbance of Q.fragosa: **Task iFi, Human disturbance: Quanti~,' the magnitude of these potential threats (harvesting, swimming/wading/digging, small recreational watercraft, and commercial paddlewheel watercraft) and identify specific geographic locations of greatest concern. **Task 1F2, Educational signs: Produce educational signs to inform the public of the presence of Q. fragosa, laws and penalties associated with disturbing individuals of the species, and behaviors to avoid while in critical areas. These signs should be posted at marinas, campgrounds, boat ramps and landings, and near critical mussel beds, such as at Folsom and Blast Islands. **Task 1F3, Public education: Contact and encourage educational institutions to conduct educational programs on Q. fragosa. These institutions should include the National Park Service, state parks (St. Croix, Wild River, Interstate, William O'Brien, Afton, and Kinnickinnic), the Science Museum of Minnesota, Carpenter and Wilder Nature Centers, and local conservation groups. **Task 1F4, Paddle wheel boats: Request owners of the commercial paddle wheel boat to review their operating procedures with the intent of minimizing their boat operation's impact on the mussel population. Task iG, Water quality: The following actions are recommended to address the issue of water quality: Task iGi, Water quality classification: Review the classification status for water quality in the St. Croix River for both Minnesota and Wisconsin and recommend changes in classification, as appropriate to protect 0. fragosa. Task 1G2,Ammonia: Monitor the river for ammonia to better determine sources and concentration level trends. The report should address both chronic and acute ammonia pollution. Task 1G3,Point discharge impacts: Perform detailed water chemistry analysis from above and below point discharge facilities and assess the effects of measurable discharges on Q. fragosa. Task 1G4, Point discharge permits: Review point source discharge data on file at Minnesota Pollution Control Agency and Wisconsin Department of N

- Task 2: Improve understanding of Q. fragosa biology and ecology. The following sub-tasks are to provide information critical to devising actions to preserve Q. fragosa. Many of the subtasks must be completed for successful completion of sub-tasks described in Tasks 1, 3, 4, and 5. Task 2A, Systematics: Further work is needed to determine taxonomic relationships within the Q. quadrula complex and to determine the appropriateness of species designation for Q. fragosa. Task 2A1, Molecular systematics: Conduct molecular studies on existing Q. fragosa material. This study should include the population of Quadrula found in the Kiamichi River, Oklahoma, and all members of the Q. quadrula complex. Task 2A2, Conchology: Compare shell morphology of the Kiamichi River and St. Croix River populations and all members of the Q. quadrula complex. Task 2A3, Soft body morphology: Describe the soft-body morphology ofQ. fragosa and all members of the Q. quadrula complex. **Task 2A4, Glochidia: Describe the glochidia of all members of the Q. quadrula complex. Task 2B, Habitat requirements: Further work is required to identify specific habitat features usable for habitat suitability determinations for Q. fragosa. It is not known why Q. fragosa occurs where it does generally nor what limits its distribution within the St. Croix River itself. **Task 2B1, St. Croix habitat: Produce a report on an extensive comparison of the reach Q. fragosa inhabits with upstream and downstream reaches where it is not found to identify significant habitat limiting parameters. Review Wisconsin Department of Natural Resources distributional and habitat data in conjunction with this task. Task 2B2, Historical distribution: Review the rivers comprising the historical distribution ofQ. fragosa to assess the historical water quality parameters and other available historical trend data. Parameters to be included are: oxygen, temperature, chlorine, phosphorus, ammonia, calcium, alkalinity, total organic carbon, metals, pesticides (including herbicides), suspended solids, stream flow, pH, sodium, and potassium. **Task 2B3, Microhabitat: Because only 26 individual Q. fragosa have been studied, continue intensive microhabitat study to better identify habitat needs (substrate, depth, flow rate, etc.) of Q. fragosa. Task 2B4, Scour: Evaluate and produce a report on unionid susceptibility to ice scour and exposure in winter and flood scour in spring. Evaluate ice impacts during naturally low flow and run-of-river vs. hydropeaking flow conditions. Task 21B5, Sediment deposition: Evaluate and produce a report on sediment deposition patterns and unionid susceptibility to sediment deposition. **Task 2B6, Dewatering: Determine the effects of dewatering and of low and high temperatures on unionids. The report should include a discussion of how these parameters effect survivorship and reproduction. Task 2C, Reproductive biology: An improved knowledge of the reproductive biology of this species is required to make sound management decisions. **Task 2C1, Reproductive phenology: Determine the phenology of reproduction. **Task 2C2, Glochidial host: Identify the glochidial host(s). **Task 2C3, Glochidial host distribution: Determine the distribution and abundance of glochidial host(s) population(s) in the St. Croix River. **Task 2C4, Reproductive parameters: Determine other factors that influence reproductive success (fecundity, sex ratio, density, spacing of adults, or external environmental factors). Task 2D, Population biology: An improved knowledge of the population biology of this species is required to make sound management decisions. Task 2D1, PVA and MVP: Conduct a Population Viability Analysis (PVA) to determine the Minimum Viable Population (MVP) for a discrete population ofQ. fragosa. Task 2D2, Demographic patterns: Determine normal growth rates and age structure from museum specimens and data from the St. Croix River. Task 2D3, Historic distribution: Study museum specimens to better establish historic range and number of pre-settlement populations. Task 2D4, Number of populations: Estimate the number of discrete populations needed to maintain the species and the optimal geographic distribution for those populations. Task 2E, Population survey: **Task 2E1, St. Croix River: Complete a survey of the St. Croix River and its tributaries to improve our knowledge of the extent of the population and to improve estimates of population size. A survey is needed from the dam at St. Croix Falls downstream to Marine on St. Croix and upstream from the dam to the confluence of St. Croix and Namekagon Rivers. Review Wisconsin Department of Natural Resources surveys reports on substrate and mussel distribution. Task 2E2, Historic distribution: Finish the field survey of rivers having historic distribution of Q. fragosa. Highest priority should be given to stretches just below dams in: 1) The Kiamichi River, Oklahoma; 2) Duck River, Tennessee, which has a recent record of a “strange looking Q. quadrula, which might have been Q. fragosa” (S. Ahlstedt, Tennessee Valley Authority, Aquatic Biology Laboratory, Norris, Tennessee, in lift. 1991); 3) Rivers thought to have historically had large populations ofQ. fragosa (Iowa and Raccoon Rivers, Iowa); and 4) Rivers having relatively undisturbed watersheds or water quality characteristics similar to the St. Croix River.

- Task 3: Increase the St. Croix population of Q. fragosa. Translocation of mussels is problematic and has resulted in high mortality rates during transportation or shortly after transportation and there is a dearth of knowledge about the longterm viability of translocated unionids. Additionally, ex-situ culture techniques are poorly developed and few species have been successfully cultured. The population in the St. Croix River is so small that it is too risky to attempt either translocation or aquaculture of this species until either methodologies improve or the population in the St. Croix increases significantly. Task 3A, Increase St. Croix population: Task 3A1, Feasibility study: Perform a feasibility study to determine the relative merits and likely success of attempts to increase the population size ofQ. fragosa in the St. Croix River vis d vis attempts to translocate individuals to initiate new populations. This feasibility study should utilize the results of tasks outlined in Tasks 2, 4A, and 4B. Task 3A2, Plan to increase St. Croix population: If, upon completion of Task 3A1, it is deemed feasible to increase the St. Croix River population, then a plan to do so should be developed and implemented.
- Task 4: Reestablish Q.fragosa populations in historical range. Small, localized populations are very susceptible to environmental stochasticity (Gilpin and Souls 1986). The long-term viability of Q. fragosa depends on establishing more than one discrete population. There are no data which suggests a particular number of populations confers longterm protection from negative, stochastic environmental and genetic events. Theoretical considerations (Simberloff 1988), however, suggest a metapopulation comprised of several subpopulations confers more long-term stability on a species than fully isolated populations. Task 4A, Translocation: Task 4A1, Translocation protocol: Evaluate translocation techniques and establish a translocation protocol. Task 4A2, Suitable habitat: Identify rivers within the historical distribution of 0. fragosa which have suitable physical, chemical, and biological habitat for reintroduction of Q. fragosa. Give priority to the following factors when selecting translocation sites: a) Rivers close to the St. Croix so environmental and climatic factors will be similar to those to which the St. Croix River population is adapted and so new populations might function as a metapopulation. b) Rivers having sufficient long-term protection (such as mussel sanctuaries, state or National parks) so they will qualify under the guidelines for population habitat protection in Task SC. c) Rivers at low risk from colonization by Dreissena spp. Task 4B, Mussel culture and propagation: Task 4B1, in situ vs. ex situ: Evaluate in situ vs. ex situ approaches to recovery and develop methods consistent with the findings. Task 4B2, Mussel cultivation: Generally improve the knowledge of mussel cultivation.
- Task 5: Determination of reclassification and delisting. Task 2D4 will establish the appropriate number and distribution of populations of Q.fragosa. Task 5A, Determination of population viability: A population may be counted toward reclassification or delisting only

after the following tasks are performed to demonstrate its viability: Task SAl, Recruitment: Conduct surveys until data demonstrate recruitment to the population in 8 of the 11 age classes aged 2 to 12 years. Task 5A2, Population size: Conduct surveys until data demonstrate the population likely exceeds the MVP determination made in Task 2D1. Task 5A3, Age structure: Conduct surveys until data demonstrate the population has an age structure consistent with the MYP determination made in Task 2D1. Task 5A4, Genetic structure: Conduct surveys until data demonstrate the population has a genetic structure consistent with the MYP determination made in Task 2D 1. Task SB, Determination of population persistence: A population may be counted toward reclassification or delisting only after the following tasks are performed to demonstrate its persistence: Task 5B1, Longevity: The population must have been extant for 24 years following colonization or establishment. Task 5B2, Population surveys: Three consecutive surveys taken at approximately 5-year intervals must demonstrate population levels to exceed the MYP determination made in Task 2D1. Task SC, Determination of habitat protection: A population may be counted toward reclassification or delisting only after the following tasks are performed to demonstrate its habitat is protected: Task 5C1, Watershed management plan: A watershed management plan must be drafted and approved by the Service which demonstrates all potential threats to the population have been identified and either eliminated, mitigated, or otherwise provided for. The factors to be included in this plan should be similar to those outlined in this document for protection of the St. Croix Population in Task 1 and must include: a) Physical habitat. b) Chemical habitat. c) Biological habitat. d) Protection from commercial harvest. e) Protection from toxic spills.

- 1) Wisconsin listed Q.fragosa as a state endangered species in 1989 (State of Wisconsin 1989) and Minnesota listed Q.fragosa as a state endangered species in 1996 (State of Minnesota 1996).
- 2) Although not intended as a winged mapleleaf mussel conservation or recovery measure, establishment of the St. Croix National Scenic Riverway in 1968 has contributed to the conservation of the species.
- 3) The National Park Service has posted signs at Interstate Park prohibiting the handling of mussels (U.S. Code of Federal Regulations, Title 36 CFR 2.1(C) (1)).
- 4) The Wisconsin Department of Natural Resources prohibited commercial clamming on the St. Croix River in 1986 (State of Wisconsin 1986) and Minnesota Department of Natural Resources has restricted commercial clamming to the Mississippi River.
- 5) An important conservation measure addressing instream flow began before Q. fragosa was listed and continued following listing. Northern States Power Company-Wisconsin and the Minnesota and Wisconsin Departments of Natural Resources engaged in dialogue, study, and action described in some detail below.
- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Revise the recovery criteria and tasks to reflect the change in the species' status due to the discovery of four additional populations and other changes since 1997. 2. Describe the magnitude and immediacy of threats to the four newly discovered Q. fragosa populations and update that information for the St. Croix River population. Rank threats in priority - high, medium, and low - and describe actions that should be taken to address each threat, beginning with the high priority threats and proceeding to low priority threats. 3. If spills of toxic materials are a threat to one or more populations, develop spill contingency plans to minimize the likelihood of significant adverse effects to the potentially affected populations. 4. Complete sampling needed to describe the abundance and distribution of Q. fragosa in the Bourbeuse River, Little River, Ouachita River,

and Saline River. 5. Determine whether additional populations of Q. fragosa should be established to consider the species for reclassification or delisting. That is, are three and five populations, respectively, sufficient to consider the species for reclassification or delisting? Important considerations include: conserving the species' genetic diversity and ensuring that the species is able to withstand demographic and environmental variation. 6. Revise the recovery criteria to include practicable metrics for determining population viability and persistence. These metrics must be feasible to implement in light of likely funding and logistical constraints and should minimize disturbance of benthic organisms and their habitats. The Service should then develop methods to assess the status of Q. fragosa populations in light of the metrics. 7. Convene the recovery team to identify any research questions that, if answered, would be likely to have a significant benefit to our ability to propagate Q. fragosa (USFWS, 2015).

References

Recovery plan

USFWS 2015. Winged Mapleleaf (Quadrula fragosa) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Twin Cities Field Office, Bloomington MN. 71 pp.

USFWS. 2015. Winged Mapleleaf (Quadrula fragosa). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Twin Cities Field Office Bloomington, Minnesota. 24 pp.

Nature serve, recovery plan, five year review

USFWS. 2015. Winged Mapleleaf (Quadrula fragosa). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Twin Cities Field Office Bloomington, Minnesota. 24 pp.

USFWS. 2024. Winged Mapleleaf (Quadrula fragosa) Status Review: Summary and Evaluation. Minnesota-Wisconsin Field Office. Bloomington, Minnesota. 22 pages.

recovery plan

Recovery Plan

SPECIES ACCOUNT: *Quadrula intermedia* (Cumberland monkeyface (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 06/14/1976, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

A medium-size freshwater mussel or bivalve mollusk with a greenish-yellow to yellowish-green shell that darkens with age. (NatureServe, 2015)

Taxonomy

Quadrula intermedia has been synonymized in the past with Quadrula tuberosa and Quadrula sparsa (Ortmann, 1918). The relationship to Quadrula tuberosa, Quadrula intermedia, and Quadrula sparsa is questionable; however, both Q. tuberosa and Q. sparsa have been found historically within the range of Q. intermedia and no intergrade specimens have been found (USFWS, 1984). Q. tuberosa may be the form of Q. intermedia occurring in big rivers, where a more obese form typically occurs in many unionid species. Quadrula sparsa is currently recognized by Turgeon et al. (1998). Distributional records became confused when Ortmann (1914; 1918) lumped Quadrula sparsa and Quadrula tuberosa under Quadrula intermedia (Bogan and Parmalee, 1983; Parmalee and Bogan, 1998). Historical records for Q. tuberosa from the Cumberland River are therefore also included with historical records for Q. sparsa (USFWS, 1984) but if these are distinct species, then Q. sparsa was not present in the headwaters of the Cumberland River (Parmalee and Bogan, 1998). At Muscle Shoals, Morrison (1942) described a more inflated form as Quadrula biangulata and shells similar to this form have been recovered from archaeological remains in the lower Clinch River, Tennessee, and identified as Quadrula sparsa (Parmalee and Bogan, 1986). Parmalee and Bogan (1998) placed Q. biangulata in the synonymy of Quadrula quadrula. Whether or not the biangulata form represents a valid species is unclear as it is conchologically different from typical Q. intermedia but appears to represent one extreme in range of variation of the species. Williams et al. (2008) tentatively place it in synonymy with Q. sparsa. (NatureServe, 2015)

Historical Range

Historically, this species was widespread in the upper Tennessee River system (Tennessee, Elk, Duck, Holston, north and south fork Holston, Nolichucky, French Broad, Tellico, Clinch, Powell Rivers) (Simpson, 1914; Ortmann, 1918) in Tennessee, Alabama, and Virginia, and possibly in the Cumberland River system (Cumberland, Big South Fork Cumberland, Caney Fork) where its former occurrence remains uncertain because the closely related Quadrula tuberosa was also reported there (USFWS, 1984). It is likely that Ortmann's 1918-1925 records for the Cumberland River system were probably Quadrula tuberosa, here recognized as a synonym of Quadrula intermedia (USFWS, 1984). Since 1960, it has been found in large tributaries of the Tennessee River including the Duck, Clinch, Elk and Powell Rivers. It appears to be extirpated from Alabama, although reintroduction efforts are underway (Mirarchi et al., 2004). (NatureServe, 2015)

Current Range

Since 1970, it has been found only in the Clinch, Powell and Tellico Rivers (USFWS, 1984). It was recently found alive in the Duck River in Tennessee (Louis Levine, pers. comm. 10/7/1997). (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Water is siphoned during feeding and respiration (Stein, 1971) (USFWS, 1982).

Reproduction Narrative

Adult: This species is a short-term brooder. Host fishes may include the Tennessee shiner, streamline chub, and blotched chub. Gravid females are found in May and June. Thin-sectioned fresh dead shells collected during a 2008-09 Powell River survey ranged in age from 7-35 years (USFWS, 2011).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits shallow riffle and shoal areas of headwater streams and bigger rivers. It prefers clean, fast-flowing water in shoal conditions, and has never been found in the ponded stretches of rivers, nor is it known from small streams (USFWS, 1984). It has been found living in a sand and gravel substrate in 6 inches to 2 feet of water (Bogan and Parmalee, 1983). The environmental specificity of this species is narrow and it is highly vulnerable. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of >90% (NatureServe, 2015)

Species Trends:

Stable (USFWS, 2011)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

The range of this species was formerly restricted to the upper Tennessee River system but was never abundant (Simpson, 1914; USFWS, 1984). It was reported from the upper Elk River, Tennessee (Isom et al., 1973). It is extirpated from the Upper Clinch, and North and South Fork Holston Rivers (USFWS, 1984) and has not been seen in Alabama in the Tennessee River downstream of Muscle Shoals since the river was impounded in the early 1900s (Mirarchi, 2004; Williams et al., 2008). Still, it has declined significantly throughout its range now found in only 2 or 3 rivers (most not viable). This species has experienced a long-term decline of >90%. The range extent is 400 - 2,000 square miles, with an estimated population size of up to 1,000 individuals. There are up to 5 occurrences, but none of these occurrences have good viability/integrity (NatureServe, 2015). The species status is stable, based on the 2010 Recovery Data Call (USFWS, 2011).

Threats and Stressors

Stressor: Habitat degradation and modification (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Threats include impoundment (for flood control, navigation, hydroelectric power production, and recreation) including Norris Dam and Columbia Dam, siltation (due to strip mining, coal washing, dredging, farming, logging, and road construction), and pollution (municipal, agricultural, and industrial) from sawdust (logging), coal mine acids, toxic wastes, gravel dredging, fertilizers, pesticides, chemical spills and discharges (USFWS, 1984) (NatureServe, 2015).

Stressor: Small, isolates populations (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Rare species with small, highly disjunct populations like Quadrula intermedia may suffer various threats from inherently small population size. These threats are associated primarily with isolation and the deleterious effects of genetics (summarized in FWS 2004) (USFWS, 2011).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. A viable population of Quadrula intermedia exists in the Powell River from the backwaters of Norris Reservoir upstream to approximately PRM 130 and in the Elk River below Fayetteville, Tennessee. These two populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population (USFWS, 2011).

2. Through reestablishments and/or by discoveries of new populations, viable populations exist in two additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate Q. intermedia from the river system. (If the Duck River Columbia Dam project is not completed and a viable population of the species exists in the Duck River, only one additional viable population will be needed to meet this criterion.) (USFWS, 2011).

3. The species and its habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (USFWS, 2011).

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal-related siltation occurs in the Clinch River (USFWS, 2011).

Recovery Actions:

- Preserve populations and presently used habitat with emphasis on the Duck, Elk, and Powell Rivers
- Determine the feasibility of introducing the species back into rivers within its historic range and introduce where feasible (USFWS, 1982).
- Conduct life history studies not covered under Section 1.2; i.e. fish hosts, age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics (USFWS, 1982).
- Determine the number of individuals required to maintain a viable population (USFWS, 1982).
- Investigate the necessity for habitat improvement and, if feasible and desirable, identify techniques and sites for improvement to include implementation (USFWS, 1982).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations (USFWS, 1982).
- Assess overall success of recovery program and recommend action (delist, continued protection, implement new measures, other studies, etc.) (USFWS, 1982).
- Conduct life history research and confirm fish hosts (USFWS, 2011).
- Develop propagation technology (USFWS, 2011).
- Reintroduce viable populations in other streams within the historical range (e.g., Clinch, Nolichucky, South Fork Holston, upper Holston, Paint Rock, and Tennessee Rivers below Wilson Dam (and possibly lower French Broad/Holston and Elk Rivers if thermal, DO, and flow regimes are corrected) that have suitable habitat and water quality conditions, through propagation of juveniles and/or release of infected host fishes (USFWS, 2011).
- Augment and expand extant populations (primarily the Duck River) through propagation of juveniles and/or release of infected host fishes (USFWS, 2011).
- Determine viability of the Powell River population (USFWS, 2011).
- Reassess status and viability of currently known population in the Duck River in approximately five years (USFWS, 2011).
- Determine the degree of threat (especially coal mining in the Powell River and water withdrawals in the Duck River) to each stream in which this species occurs (USFWS, 2011).
- The experience from increased minimum flows, aeration improvements, and subsequent DO level increases in the Duck River from Normandy Dam tailwater discharges proves that fairly simple measures can be implemented at TVA dams to improve habitat for mussels (USFWS, 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTION The 2011 5-year review included a list of recommendations to improve recovery of the Cumberland monkeyface, these actions remain applicable to species recovery. Additional recommendations are below. • Conduct additional life history research, confirm fish hosts, and develop propagation technology. Age studies have been completed but growth and survival of age classes are lacking. Additional host fish testing and development of culture techniques are underway by VDWR. These steps are crucial in order to re-establish the species in the Elk River, Tennessee. • Reassess status and viability of currently known populations in the Powell and Duck rivers at minimum every five years. Additionally, conduct targeted surveys within both rivers to develop population estimates and effective population size targets. Continue working with TVA, TWRA, and other partners to gather quantitative and qualitative mussel community data in the Elk River, Tennessee. • Evaluate flow release benefits from operational changes at Tims Ford Dam on the upper Elk River, to assess the benefits of naturally variable seasonal flows, temperatures, and associated DO level increases on freshwater mussels. Continue mussel monitoring and riparian restoration efforts in the Elk River and explore ways to improve instream habitat conditions. • Reintroduce populations through propagation of juveniles in other rivers within the historical range that have potential for viability (e.g., Clinch, Nolichucky, upper Holston, upper French Broad, and Paint Rock rivers, as well as the Tennessee River below Wilson Dam). (USFWS, 2021)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2011. Cumberland Monkeyface (Quadrula intermedia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina

USFWS 1982. Cumberland Monkeyface Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 59 pp.

USFWS 2011. Cumberland Monkeyface (Quadrula intermedia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina.

USFWS. 2011. Cumberland Monkeyface (Quadrula intermedia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office Asheville, North Carolina.

USFWS 2011. Cumberland Monkeyface (Quadrula intermedia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Asheville Ecological Services Field Office, Asheville, North Carolina.

USFWS. 2021. Cumberland Monkeyface (Quadrula intermedia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina. 30 pp.

SPECIES ACCOUNT: *Quadrula petrina* (Texas pimpleback)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered; (USFWS, 2021)

Physical Description

The Texas pimpleback is a large pimpleback species with a moderately inflated shell that generally reaches 60 90 mm (2.43.5 in) (Howells 2002b, pp. 34). With the exception of growth lines, the shell of the Texas pimpleback is generally smooth and moderately thick (Howells 2002b, p. 4). Externally, coloration ranges from yellowish-tan to dark brown with some individuals mottled or with dark green rays. Internally, the nacre (inside of shell) is white and iridescent posteriorly (Howells 2002b, p. 4).

Taxonomy

The Texas pimpleback was originally described as Unio petrinus by Gould in 1855. It was placed in the genus Margaron by Lea in 1870 and ultimately moved to Quadrula by Simpson in 1900 (Simpson 1900, p. 783). Graf and Cummings (2007, p. 18) have proposed moving it to the genus Amphinaias, but other freshwater mussel taxonomists recommend waiting for additional work to be completed on members of Quadrula before splitting the genus (Bogan 2011, pers. comm.). The Texas pimpleback is recognized by the Committee on Scientific and Vernacular Names of Mollusks of the Council of Systematic Malacologists, American Malacological Union (Turgeon et al. 1998, p. 37), and we recognize it as a valid species.

Historical Range

The Texas pimpleback is endemic to the Colorado and Guadalupe-San Antonio River basins of central Texas (Howells 2002b, p. 3). In the Colorado River basin, Texas pimpleback occurred throughout nearly the entire mainstem, as well as numerous tributaries, including the Concho, North Concho, San Saba, Llano, and Pedernales Rivers, and Elm and Onion Creeks (Howells 2010e, p. 5; Randklev et al. 2010c, p. 4; OSUM 2011d, p. 1). Within the Guadalupe-San Antonio River basin, it occurred throughout most of the length of the Guadalupe River, as well as in the San Antonio, San Marcos, Blanco, and Medina Rivers (Horne and McIntosh 1979, p. 122; Howells 2010e, p. 5; OSUM 2011d, p. 1).

Current Range

The Texas pimpleback has declined significantly rangewide, and only four streamsthe lower Colorado River, San Saba River, Concho River, Guadalupe River, and San Marcos Riverare known to harbor persisting Texas pimpleback populations. All but two of these populations are disjunct, small, and isolated. The species has been extirpated from the remainder of its historical range.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes;

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli), and threatened species status for the Texas fawnsfoot (Truncilla macrodon), seven species of freshwater mussels from central Texas. We also issue a rule under section 4(d) of the Act for the Texas fawnsfoot that provides measures that are necessary and advisable to provide for the conservation of the Texas fawnsfoot. In addition, we designate critical habitat for all seven species. In total, approximately 1,577.5 river miles (2,538.7 river kilometers) in Blanco, Brown, Caldwell, Coleman, Comal, Concho, DeWitt, Gillespie, Gonzales, Guadalupe, Hays, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, Palo Pinto, Parker, Runnels, San Saba, Shackelford, Stephens, Sutton, Throckmorton, Tom Green, Travis, and Victoria Counties, Texas, fall within the boundaries of the critical habitat designation. This rule applies the protections of the Act to these species and their designated critical habitat (89 FR, 48034)

Critical Habitat Designation

Critical habitat units are depicted for Brown, Coleman, Concho, Kimble, Lampasas, Mason, McCulloch, Menard, Mills, Runnels, San Saba, and Tom Green Counties, Texas.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of Texas pimpleback consist of the following components within waters and streambeds up to the ordinary high-water mark:

(i) Flowing water at rates suitable to keep riffle habitats wetted and welloxygenated and to prevent excess sedimentation or scour during high-flow events but not so high as to dislodge individuals

(ii) Stable riffles and runs with substrate composed of cobble, gravel, and fine sediments

(iii) Channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis olivaris), and tadpole madtom (Noturus gyrinus) present

(iv) Water quality parameters within the following ranges: (A) Dissolved oxygen greater than 2 milligrams per liter (mg/L); (B) Salinity less than 2 parts per thousand; (C) Total ammonia less than 0.77 mg/ L total ammonia nitrogen; (D) Water temperature below 29 °C (84.2 °F); and (E) Low levels of contaminants.

Life History

Feeding Narrative

Larvae: Larval unionid mussels require a host.

Juvenile: For their first several months, juvenile mussels feed using cilia (fine hairs) on the foot to capture suspended as well as depositional material, such as algae and detritus (Yeager et al. 1994, pp. 253259).

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874876; Christian et al. 2004, p. 109). Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity, when energy presumably is being diverted from growth to reproductive activities (Baird 2000, pp. 6667).

Reproduction Narrative

Adult: There is very little specific information on age, size of maturity, or host fish use for Texas pimpleback. Gravid females (females with eggs inside) have been found from June through August, and the smallest documented gravid female was 45 mm (1.8 in) long (Howells 2000b, p. 38). Glochidia are hookless and elliptical in shape (Howells et al. 1996, p. 120). To date, no host fish have been confirmed for the Texas pimpleback; however, glochidia have been reported attached to and encysted on flathead catfish (Pylodictis olivaris), yellow bullhead (Ameiurus natalis), and bluegill in laboratory settings, although none transformed to the juvenile stage (Howells 2010e, p. 3). This is consistent with other species in the genus Quadrula, which also parasitize catfish species. Mussels are extremely long lived, living from two to several decades (Rogers et al. 2001, p. 592), and possibly up to 200 years in extreme instances (Bauer 1992, p. 427). Most mussel species, including Texas pimpleback, have distinct forms of male and female. During reproduction, males release sperm into the water column, which females draw in through their siphons. Fertilization takes place internally, and the resulting eggs develop into specialized larvae (called glochidia) within the females modified gill pouch (called marsupia) for four to six weeks. The females will then release matured glochidia individually, in small groups, or embedded in larger mucus structures called conglutinates. Glochidia are obligate parasites (cannot live independently of their hosts) on fish and attach to the gills or fins of appropriate host species where they encyst (enclose in a cyst-like structure) and feed off of the hosts body fluids (Vaughn and Taylor 1999, p. 913) and develop into juvenile mussels weeks or months after attachment (Arey 1932, pp. 214215). The glochidia will die if they fail to find the appropriate host fish, attach to a fish that has developed immunity from prior infestations, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 299). Mussels experience their primary opportunity for dispersal and movement within the stream as glochidia attached to a host fish (Smith 1985, p. 105). Upon release from the host, newly transformed juveniles drop to the substrate on the bottom of the stream. Those juveniles that drop in unsuitable substrates die because their immobility prevents them from relocating to more favorable habitat. Juvenile freshwater mussels burrow into interstitial substrates and grow to a larger size that is less susceptible to predation and displacement from high flow events (Yeager et al. 1994, p. 220). Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish.

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The Texas pimpleback typically occurs in moderately sized rivers, usually in mud, sand, gravel, and cobble, and occasionally in gravel-filled cracks in bedrock slab bottoms (Horne and McIntosh 1979, p. 122; Howells 2002b, p. 4). The species has not been found in water depths over 2 m (6.6 ft). Texas pimpleback have not been found in reservoirs, which indicates that this species is intolerant of deep, low velocity waters created by artificial impoundments (Howells 2002b, p. 4). In fact, Texas pimpleback appear to tolerate faster water more than many other mussel species (Horne and McIntosh 1979, p. 123).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:
4

Population Size:
Unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Based on historical and current data, the Texas pimpleback has been eliminated from long reaches of former habitat in hundreds of miles of the Colorado and Guadalupe River systems. Only two populations appear large enough to be stable, but evidence of recruitment in the Concho River population is limited. The San Saba River population may be the only remaining recruiting population of Texas pimpleback. Two additional populations are represented by one or two individuals; all populations are highly disjunct.

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: A major factor in the decline of freshwater mussels across the United States has been the large-scale impoundment of rivers (Vaughn and Taylor 1999, p. 913). Dams are the source of numerous threats to freshwater mussels: They block upstream and downstream movement of species by blocking host fish movement; they eliminate or reduce river flow within impounded areas, thereby trapping silts and causing sediment deposition; and dams change downstream water flow timing and temperature, decrease habitat heterogeneity, and affect normal flood patterns (Layzer et al. 1993, pp. 6869; Neves et al. 1997, pp. 6364; Watters 2000, pp. 261264; Watters 1996, p. 80). Within reservoirs (the impounded waters behind dams), the decline of freshwater mussels has been attributed to sedimentation, decreased dissolved oxygen, and alteration of resident fish populations (Neves et al. 1997, pp. 63 64; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 261264). Dams significantly alter downstream water quality and stream habitats (Allan and Flecker 1993, p. 36; Collier et al. 1996, pp. 1, 7) resulting in negative effects to tailwater (the area downstream of a dam) mussel populations (Layzer et al. 1993, p. 69; Neves et al. 1997, p. 63; Watters 2000, pp. 265266). Below dams, mussel declines are associated with changes and fluctuation in flow regime, scouring and erosion of stream channels, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Williams et al. 1992, p. 7; Layzer et al. 1993, p. 69; Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 265266). Numerous dams have been constructed

throughout the Colorado and Guadalupe-San Antonio River systems within the range of Texas pimpleback (Stanley et al. 1990, p. 61).

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Siltation and general sediment runoff is a pervasive problem in streams and has been implicated in the decline of stream mussel populations (Ellis 1936, pp. 3940; Vannote and Minshall 1982, p. 4105; Dennis 1984, p. ii; Brim Box and Mossa 1999, p. 99; Fraley and Ahlstedt 2000, pp. 193194). Specific biological effects on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills (Ellis 1936, p. 40), disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity (Marking and Bills 1979, pp. 208209; Vannote and Minshall 1982, p. 4106), physical smothering, and disrupted host fish attractant mechanisms (Hartfield and Hartfield 1996, p. 373). The primary effects of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999, p. 101). The physical effects of sediment on mussel habitats are multifold and include changes in suspended material load; changes in streambed sediment composition from increased sediment production and runoff in the watershed; changes in the form, position, and stability of stream channels; changes in water depth or the width-to-depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave mussels stranded (Brim Box and Mossa 1999, pp. 109112).

Stressor: Dewatering
Exposure:
Response:
Consequence:
Narrative: River dewatering can occur in several ways: Anthropogenic activities such as surface water diversions and groundwater pumping, and natural events, such as drought. Surface water diversions and groundwater pumping can lower water tables, reducing river flows and reservoir levels. When water levels in streams and reservoirs are lowered dramatically, it can result in mussels being stranded and dying in previously wetted areas. This is a particular concern within and below reservoirs where water levels are managed for purposes that result in water levels in the reservoir or downstream to rise or fall in very short periods of time, such as when hydropower facilities release water during peak energy demand periods. Drought can also severely impact Texas pimpleback populations. Central Texas, including the Colorado and Guadalupe River basins, experienced a major drought in the late 1970s (Lewis and Oliveria 1979, p. 243). Near record dry conditions in 2008 followed by a pattern of below-normal rainfall during the winter and spring of 2009 led to one of the worst droughts in recorded history for most of central Texas, including the range of the Texas pimpleback (Nielsen-Gammon and McRoberts 2009, p. 2). This droughts severity was exacerbated by abnormally high air temperatures, a likely effect of climate change, which has already increased average air temperatures in Texas by at least 1 °C (1.8 °F) (Nielsen- Gammon and McRoberts 2009, p. 22). Instream flows throughout the Colorado River basin during this drought were significantly reduced (USGS 2011c, p. 1), and Texas pimpleback populations in areas with reduced water levels may have been negatively affected.

Stressor: Sand and Gravel Mining

Exposure:
Response:
Consequence:
Narrative: Sand and gravel mining (removing bed materials from streams) has been implicated in the destruction of mussel populations across the United States (Hartfield 1993, pp. 136138). Sand and gravel mining causes stream instability by increasing erosion and turbidity (a measure of water clarity) and causing subsequent sediment deposition downstream (Meador and Layher 1998, pp. 89). These changes to the stream can result in large-scale changes to aquatic fauna, by altering habitat and affecting spawning of fish, mussels, and other aquatic species (Kanehl and Lyons 1992, pp. 411). Sedimentation and increased turbidity can accrue from instream mining activities. In the Brazos River, a gravel dredging operation was documented as depositing sediment as far as 1.6 km (1 mi) downstream (Forshage and Carter 1973, p. 697). Accelerated streambank erosion and downcutting of streambeds are common effects of instream sand and gravel mining, as is the mobilization of fine sediments during sand and gravel extraction (Roell 1999, p. 7).

Stressor: Chemical Contaminants
Exposure:
Response:
Consequence:
Narrative: Chemical contaminants are ubiquitous throughout the environment and are a major reason for the decline of freshwater mussel species nationwide (Richter et. al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007a, p. 2029). Chemicals enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal effluents, and agriculture runoff. These sources contribute organic compounds, heavy metals, pesticides, herbicides, and a wide variety of newly emerging contaminants to the aquatic environment. As a result, water quality can be degraded to the extent that mussel populations are adversely affected.

Stressor: Predation
Exposure:
Response:
Consequence:
Narrative: Raccoons will prey on freshwater mussels stranded by low waters or deposited in shallow water or on bars following flooding or low water periods (Howells 2010c, p. 12). Predation of Texas pimpleback by raccoons may be occurring occasionally, but there is no indication it is a significant threat to the status of the species. Some species of fish feed on mussels, such as common carp, freshwater drum, and redear sunfish, all of which are common throughout the range of Texas pimpleback (Hubbs et al. 2008, pp. 19, 45, 53). Common species of flatworms are voracious predators of newly metamorphosed juvenile mussels of many species (Zimmerman et al. 2003, p. 30). Predation is a normal factor influencing the population dynamics of a healthy mussel population; however, predation may amplify declines in small populations primarily caused by other factors.

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:

Narrative: Despite some State and Federal laws protecting the species and water quality, the Texas pimpleback continues to decline due to the effects of habitat destruction, poor water quality, contaminants, and other factors. The regulatory measures described above are not sufficient to significantly reduce or remove the threats to the Texas pimpleback. Based upon our review of the best commercial and scientific data available, we conclude that the lack of existing regulatory mechanisms is an immediate threat of moderate magnitude to the Texas pimpleback.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: The disjunct nature of the remaining Texas pimpleback populations, coupled with the limited ability of mussels to migrate, makes it unlikely that Texas pimpleback can adjust their range in response to changes in climate (Strayer 2008, p. 30). Climate change could affect the Texas pimpleback through the combined effects of global and regional climate change, along with the increased probability of long-term drought. Climate change exacerbates threats such as habitat degradation from prolonged periods of drought, increased water temperature, and the increased allocation of water for municipal, agricultural, and industrial use. Climate change may be a significant stressor that exacerbates existing threats by increasing the likelihood of prolonged drought. As such, climate change, in and of itself, may affect the Texas pimpleback, but the magnitude and imminence of the effects remain uncertain. Based upon our review of the best commercial and scientific data available, we conclude that the effects of climate change in the future will likely exacerbate the current and ongoing threats of habitat loss and degradation caused by other factors, as discussed above.

Stressor: Population Fragmentation and Isolation
Exposure:
Response:
Consequence:
Narrative: Most of the remaining populations of the Texas pimpleback are small and geographically isolated and thus are susceptible to genetic drift (change of gene frequencies in a population over time), inbreeding depression, and random or chance changes to the environment, such as toxic chemical spills (Watters and Dunn 1995, pp. 257258) or dewatering. Inbreeding depression can result in death, decreased fertility, smaller body size, loss of vigor, reduced fitness, and various chromosomal abnormalities (Smith 1974, pp. 350). Despite any evolutionary adaptations for rarity, habitat loss and degradation increase a species vulnerability to extinction (Noss and Cooperrider 1994, pp. 5862). Numerous authors (including Noss and Cooperrider 1994, pp. 5862; Thomas 1994, p. 373) have indicated that the probability of extinction increases with decreasing habitat availability. Although changes in the environment may cause populations to fluctuate naturally, small and low-density populations are more likely to fluctuate below a minimum viable population (the minimum or threshold number of individuals needed in a population to persist in a viable state for a given interval) (Gilpin and Soule 1986, pp. 2533; Shaffer 1981, p. 131; Shaffer and Samson 1985, pp. 148 150).

Stressor: Invasive species
Exposure:
Response:
Consequence:

Narrative: Various nonnative aquatic species pose a threat to the Texas pimpleback, including golden algae, zebra mussels, and black carp. Golden algae is a microscopic algae considered to be one of the most harmful algal species to fish and other gill-breathing organisms (Lutz-Carrillo et al. 2010, p. 24) and was first discovered in Texas in 1985. It is presumed to have been introduced from western Europe (Lutz- Carrillo et al. 2010, p. 30). Since its introduction, golden algae has been found in Texas rivers and lakes, including two lakes in central Texas (Baylor University 2009, p. 1). Under certain environmental conditions, this algae can produce toxins that can cause massive fish and mussel kills (Barkoh and Fries 2010, p. 1; Lutz-Carrillo et al. 2010, p. 24). Evidence shows that golden algae probably caused fish kills in Texas as early as the 1960s, but the first documented fish kill due to golden algae in inland waters of Texas occurred in 1985 on the Pecos River in the Rio Grande basin (TPWD 2002, p. 1). The range of golden algae has increased to include portions of the Brazos and Colorado River basins, among others, and it has been responsible for killing more than 8 million fish in the Brazos River since 1981 and more than 2 million fish in the Colorado River since 1989 (TPWD 2010a, p. 1). Although actual mussel kills in Texas due to golden algae have not been recorded in the past, we expect golden algae to negatively affect mussel populations through direct loss of host fish and toxicity. Therefore, making future golden algae blooms a threat to the Texas pimpleback. Other nonnative species, such as zebra mussels and black carp, are a potential future threat to the Texas pimpleback that is likely to increase as these exotic species expand their occupancy within the range of the Texas pimpleback.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- Continued survey and monitoring efforts are needed throughout former and occupied sites to better define the species distribution and status in the Colorado and Guadalupe-San Antonio River systems.
- Continued biological and ecological research efforts are needed to identify host fish, spawning and brooding seasons, glochidia, and habitat and physiochemical parameters for Texas pimpleback. The Service will continue to work with TPWD, United States Geological Surveys (USGS), and others needed research in order to facilitate the conservation and preservation of the Texas pimpleback.
- The Service will continue working with resource management agencies, TXDOT, and academia on the development of standard mussel survey, relocation, and monitoring protocols, which would establish a commonality among the wide variety of methods currently being used in Texas and would establish a baseline of what kind of data needs to be collected while conducting surveys.
- The Service, TPWD, academia, and other resource agencies have proposed and ongoing studies in Texas river systems for Texas freshwater mussels, including the Texas pimpleback, observing life history parameters (including determination of ecological fish hosts), survivability of juveniles, monitoring habitat, and analyzing population dynamics. In addition, TPWD has established a Mussel Watch group.

- Long-term conservation measures need to be developed to facilitate and accomplish cooperative efforts between resource management agencies and private landowners. The development of candidate conservation agreements (with assurances) with interested parties would initiate conservation for the Texas pimpleback.
- The Service will continue working with resource management agencies and academia on developing a drought contingency plan that will facilitate the management and monitoring of mussel populations that harbor species of concern (i.e. the Texas pimpleback) during times of drought.
- The Service will continue working with resource management agencies and the Texas Department of Transportation (TXDOT) on developing best management practices for proposed adjacent and instream impacts specific to Texas water systems.

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2014. USFWS. 2021. Proposed Endangered. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. FR Vol. 86, No. 163. Pages 47916-48011.

89 FR. No. 108. Pages 48034-48130. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, Balcones Spike, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. Final Rule.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2019

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2020

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM
05/30/2021

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM
05/30/2022

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM
05/30/2023

SPECIES ACCOUNT: *Quadrula sparsa* (Appalachian monkeyface (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 06/14/1976, 10/15/2007; Northeast Region (R5), Southeast Region (R4) (USFWS, 2016)

Physical Description

A medium sized (7 cm) freshwater mussel with a yellow-green or brown shell that is marked with strong concentric growth rings, tubercles, and small greenish triangles or chevrons. (NatureServe, 2015)

Taxonomy

Distributional records became confused when Ortmann (1914; 1918) lumped Quadrula sparsa and Quadrula tuberosa under Quadrula intermedia (Bogan and Parmalee, 1983; Parmalee and Bogan, 1998). Historical records for Q. tuberosa from the Cumberland River are therefore also included with historical records for Q. sparsa (USFWS, 1984) but if these are distinct species, then Q. sparsa was not present in the headwaters of the Cumberland River (Parmalee and Bogan, 1998). (NatureServe, 2015)

Historical Range

Historically, this species was thought to have been widespread in the tributaries of the upper Tennessee and Cumberland river systems (including the Tennessee River, Holston River, Powell River, Clinch River, Cumberland River, Big South Fork Cumberland River, and Caney Fork) (USFWS, 1984). Distributional records became confused when Ortmann (1914; 1918) lumped Quadrula sparsa and Quadrula tuberosa under Quadrula intermedia (Bogan and Parmalee, 1983; Parmalee and Bogan, 1998). Historical records for Q. tuberosa from the Cumberland River are therefore also included with historical records for Q. sparsa (USFWS, 1984) but if these are distinct species, then Q. sparsa was not present in the headwaters of the Cumberland River and they can be attributed to Q. tuberosa (Parmalee and Bogan, 1998). Parmalee and Bogan (1998) claim the only confirmed records from Tennessee are from the Holston River, the upper Powell River (Claiborne and Hancock Cos.), and the unimpounded portion of the Clinch River above Norris Dam. Recent archaeological records have shown this species occurrence at Muscle Shoals and Hobbs Island in Madison Co., Alabama, but it is now extirpated from that state (Mirarchi et al., 2004; in appendix 1.2 published separately; Williams et al., 2008), as well as archaeological specimens from the lower Clinch River in Roane Co., Tennessee and Hiwassee River in Bradley Co., Tennessee (Parmalee and Bogan, 1998). (NatureServe, 2015)

Current Range

Currently, it is restricted to free-flowing reaches of the upper Powell and Clinch Rivers above Norris Reservoir in (Hancock and Claiborne Cos.) Tennessee (USFWS, 1984; Parmalee and Bogan, 1998) and in one section of the Powell and Clinch rivers in Virginia (Neves, 1991; Ahlstedt, 1991) but has nearly disappeared from this latter locality (Parmalee and Bogan, 1998). (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Water is siphoned during feeding and respiration (USFWS, 1983).

Reproduction Narrative

Adult: The glochidial host is not known (NatureServe, 2015). Females are gravid for only a few weeks in early summer. Other members of the Quadrula genus are tachytictic. Freshwater mussels may live up 50 or more years. (USFWS, 1983).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate to broad (NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species inhabits fast-flowing, headwaters sections of rivers in shallow riffles and runs (USFWS, 1984). The environmental specificity of this species is moderate to broad and it is highly vulnerable due to slow growth and immobility. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). Q. sparsa is typically found in shallow, fast-flowing water with stable, clean substrate (USFWS, 1983).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of >90% (NatureServe, 2015)

Species Trends:

Declining (NatureServe, 2015)

Number of Populations:

Likely functionally extirpated (USFWS, 2020)

Population Size:

Likely functionally extirpated (USFWS, 2020)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Due to slow growth and relative immobility, establishment of sustainable, viable populations requires decades of immigration and recruitment, even where suitable habitat exists (Neves, 1993). Mussel recruitment is typically low and sporadic, with population stability and viability maintained by numerous slow-growing cohorts and occasional good year classes (Neves and Widlak, 1987). Only the Powell and Clinch Rivers have extant populations and these have been reduced to questionable viability. All other populations have gone extinct (USFWS, 1984) with the two or three remaining populations of questionable viability, at best (Parmalee and Bogan, 1998; Ahlstedt, 1991). Occurrences in Alabama are based on archaeological material from prehistoric middens along the Tennessee River in Muscle Shoals and Hobbs Island in Madison Co. [note map is incorrect in Williams et al., 2008] (Morrison, 1942). This species has experienced a long-term decline of >90%. The range extent is less than 40 square miles, with an unknown population size. There are 2 - 3 occurrences, with none having good viability/integrity. Age studies indicate little recruitment outside a small 0.8 km linear stretch of the river in recent years (Johnson, 2011). (NatureServe, 2015). Early survey records and archeological finds of the Appalachian Monkeyface indicate the species once occurred in the headwaters of the Cumberland River system and the upper Tennessee River system (Service 1984). However, the species has only been confirmed from the Powell, Clinch, and Holston Rivers in the upper Tennessee River system. The population in the Holston River system was extirpated at the time of listing. Little is known about the population in the Clinch River due to the rarity of records. One individual discovered during a 2002 survey was the first live individual documented in the Clinch River since 1983. If there are individuals remaining in the Clinch River, the population is likely not viable and is considered functionally extirpated. The population in the Powell River persists at low levels in a 46-mile reach, located between Yellow Shoals Ford, Claiborne County, TN (PRM 84.8) and Flanary Bridge, Lee County, VA (PRM 130.6) and finding live specimens has become increasingly rare. With only one population remaining, this species has a high probability of extinction within the foreseeable future. The AWCC is currently working to evaluate host fish suitability and identify suitable methods for holding and caring for this species over an extended time period, which will provide valuable information on culture techniques as well as captive care protocols. Propagation, augmentation, and reintroduction will be essential for the survival and recovery of this species. (USFWS, 2020)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Much of th ehistoric range of Quadrula sparsa was lost through construction of dams that converted important river habitat into reservoirs. More than 50 impoundments on the Tennessee and Cumberland Rivers have eliminated most of the desired habitat for the species. The remaining populations of the Appalachian monkeyface are threatened by pollutants and excessive sediments derived from agriculture, development, and fossil fuel extraction and processing activities from coal and gas. Activities such as excluding livestock from streams and creating vegetated buffers along the streams have been and continue to be implemented and benefit not only the Appalachian monkeyface but other co-occurring listed species (USFWS, 2011).

Stressor: Low reproduction rate (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: There is little evidence to suggest that the remaining populations of the Appalachian monkeyface are reproducing at a rate that can sustain the species long term. Efforts to propagate the Appalachian monkeyface using laboratory methods have been attempted, but the difficulty in finding brooding females has led to little success (USFWS, 2011).

Recovery

Reclassification Criteria:
No downlisting criteria are given in the recovery plan (USFWS, 2007).

Delisting Criteria:
1. Restore the viability of the Clinch and Powell River populations (USFWS, 2007).

2. Reestablish or discover viable populations in one additional river (USFWS, 2007).

3. Ensure that the species is protected from present and foreseeable threats to the continued existence of any population (USFWS, 2007).

4. Determine that there are noticeable improvements in coal-related problems and substrate quality in the Powell River and that no increase in coal-related sedimentation has occurred in the Clinch River (USFWS, 2007).

Recovery Actions:

- Preserve existing populations and habitat (USFWS, 1983).
- Determine the feasibility of introducing the species back into rivers within its historic range and introduce where feasible (USFWS, 1983).
- conduct life history studies not covered under section 1.2 above; i.e., fish hosts, age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics (USFWS, 1983).
- Determine the number of individuals required to maintain a viable population (USFWS, 1983).
- Study the need for habitat improvement in areas where the species exists and where it could be introduced and, if feasible and desirable, identify techniques and sites for improvement (USFWS, 1983).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations (USFWS, 1983).
- Assess overall success of recovery program and recommend action (delist, continued protection, implement new measures, other studies, etc.) (USFWS, 1983).
- Not available

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Continue life history studies and determine suitable hosts for propagation. 2. Continue captive propagation and culture techniques. 3. Pursue reintroduction of propagated animals to the Clinch River or translocation of Powell River animals to the Clinch River. 4. Establish SSPMs to satisfy Term and Condition 1 of the 1996 Biological Opinion, titled Section 7 Formal Consultation and Conference Report on Surface Coal Mining and Reclamation Operations under the Surface Mining Control and Reclamation Act of 1977. 5. Pursue and adopt protective water quality criteria of known and suspected pollutants. 6. Identify and characterize the magnitude of specific threats (e.g., coal mining, oil and gas drilling, agriculture, urbanization, silviculture, Abandoned Mine Land [AML] sites) to allow implementation of effective measures to reduce stressors to this species. 7. Through various means of land protection (land acquisition, Best Management Practices programs, conservation easements) abate nonpoint source impacts and direct habitat loss. (USFWS, 2020)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 1983. Appalachian Monkeyface Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 55 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2020. Appalachian Monkeyface (Quadrula sparsa) (Lea, 1841) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southwestern Virginia Field Office Abingdon, Virginia. 26 pp.

USFWS. 2011. Appalachian Monkeyface (Pearlymussel) Quadrula sparsa, Species Summary. U.S. Fish and Wildlife Service, Hadley, MA. May, 2011. URL: https://www.fws.gov/northeast/pdf/MonkeyfaceMussel.pdf

USFWS 2007. Endangered and Threatened Wildlife and Plants

Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461.

Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee. 72 Federal Register 177. September 13, 2007. Pages 52434 - 52461

USFWS. 2020. Appalachian Monkeyface (Quadrula sparsa) (Lea, 1841) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southwestern Virginia Field Office Abingdon, Virginia. 26 pp.

SPECIES ACCOUNT: *Simpsonaias ambigua* (Salamander mussel)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

Salamander Mussel is a small species, elliptical in shape, that is thin-shelled and that reaches approximately 48–51 mm long (1.5–2 inches) (USFWS, 2023).

Taxonomy

The Salamander Mussel belongs to the family Unionidae, also known as the naiads or pearly mussels. The Salamander Mussel SSA report follows the most recently published and accepted taxonomic treatment of North American freshwater mussels as provided by Williams et al. (2017, entire). Salamander Mussel is the only living member of the genus Simpsonaias, and its phylogenetic position is obscure because it is not closely related to any other living species (Clarke 1985, pp. 60–68) (USFWS, 2023).

Historical Range

The Salamander Mussel was historically found across 14 states (Arkansas, Missouri, Tennessee, Kentucky, Iowa, Illinois, Indiana, Minnesota, Wisconsin, Michigan, Ohio, Pennsylvania, New York, and West Virginia) and one Canadian province (Ontario). It occurred in small streams to large rivers and in Lake Erie. It has been extirpated within Iowa and can be found within the Mississippi river only along the eastern border of the state. Other portions of the range are historical as well including Lake Erie. Much of Illinois' historical range has been diminished to four populations (USFWS, 2023).

Current Range

We used the HUC2 scale to delineate our representation units for Salamander Mussel: Upper Mississippi, Ohio, Tennessee, Great Lakes, and Arkansas-White-Red. The species currently ranges across all five representation units. We used the HUC8 at the subbasin scale to define a population of Salamander Mussel and conduct our current condition analysis. We categorized a population's status as extant, presumed extant, presumed extirpated, extirpated, or historical to assess the health, number, and distribution of populations through time. We analyzed current condition for extant and presumed extant populations (total of 66 populations). Given the paucity of data and lack of survey effort specifically for Salamander Mussel, we have minimal demographic data from a small number of populations across the range. We assessed demographic population condition as high, moderate, low, or functionally extirpated based on demographic criteria. We assigned an estimate of the probability of persistence over 20 years (approximately 2 generations of Salamander Mussel) for each population condition category based on the population's ability to withstand demographic stochastic events. For the majority of populations, we have data from incidental observations only, which does not allow us to evaluate demographic population condition (categorized as "unknown"). For our current condition analysis, we also evaluated the six primary risk factors affecting Salamander Mussel (water quality/contaminants, hydrological regime, landscape, connectivity, invasive species, and host species vulnerability). We assigned these risk factors to three categories of high, moderate, and low risk and assigned a probability of persistence over 20 years for each of the risk categories (USFWS, 2023).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Food/Nutrient Narrative

Adult: Adult freshwater mussels, including Salamander Mussel, feed by filtering suspended particles including phytoplankton, zooplankton, rotifers, protozoans, detritus, and dissolved organic matter from the water column or sediments (Table 2.1, Figure 2.2; Strayer et al. 2004, pp. 430– 431). Juvenile mussels collect food items from sediments and water column (Vaughn et al. 2008, pp. 409–411). A very small amount of carbon is transferred from the fish to the cells that glochidia have clamped down on in the gills (M. Bradley, personal communication, 2021). Availability of nutrients is critical to the survival of mussels at the individual level. In general, the availability of nutrients is not considered a limiting factor except in cases where localized risk factors (for example, elevated water temperature, increased particle number, high flow causing aperture closing) are present that change the behavior of mussels' filtering capacity or an invasive species is present in such abundance that competition for resources becomes an issue (for example, competition with Zebra mussels for food) (USFWS, 2023).

Dependency on Other Individuals or Species

Adult: Host fish: Mudpuppy

Reproduction Narrative

Adult: In general, reproduction in mussels starts with males releasing sperm into the water column and nearby females taking in sperm through their incurrent aperture (Figure 2.1). The sperm fertilize eggs in the suprabranchial chamber (dorsal part of the gills) as ova are passed from the gonad to the marsupia (Haag 2012, pp. 37–42). The developing larvae remain in the gill chamber until they mature into larvae called glochidia and are ready for release (Haag, pp. 37–42). The Salamander Mussel lives for approximately 10 years. The age of sexual maturity is not known. Salamander Mussel spawns in the spring and is bradytictic, meaning it is a long-term brooder in which the female holds the glochidia in its marsupial gills over the winter until release the following spring or summer (Watson 2001, p. 5) Salamander Mussel glochidia are considered "morphologically depressed," meaning the valve height is less than or equal to the valve length. This is significant because this type of glochidia is less likely to contact a host, though once they do, they are more likely to stay clamped on to their host (Watson 2001, p. 5). Time from encystment (where host tissue grows over glochidia that are attached to gills) to excystment (where metamorphosis occurs and glochidia transform to juveniles and break through tissue to drop off to substrate) based on propagation studies is approximately 19–28 days (Watson 2001, p. 5; M. Bradley, personal communication, 2021). Salamander Mussel has an obligate parasitic relationship with its host the mudpuppy (Figure 2.1; Table 2.1). Mudpuppy (Necturus maculosus) is the only host of Salamander Mussel and is the only non-fish host used in North America. For Salamander Mussel to complete reproduction, mudpuppy must be present during glochidia release in the summer. Mudpuppies are more resident (do not travel long distances) during the portion of the year when Salamander Mussel release glochidia resulting in encystment and excystment on mudpuppy. It is thought that mudpuppies may consume Salamander Mussel adults and therefore become infested (USFWS, 2023).

Habitat Type

Adult: Rivers/Streams/Lakes (USFWS, 2023)

Habitat Narrative

Adult: Salamander Mussel inhabits rivers, streams, and in some cases lakes with natural flow regimes. Seasonal low flow is expected in some systems and can be tolerated by Salamander Mussel, though periodic drying or intermittent flow in lake and river habitats generally cannot support mussel assemblages. Appropriate flow and temperature are critical to delivering oxygen and nutrients for respiration and filtration, allowing glochidia to move to their host and encyst for reproduction, and removing silt and other fine sediments from within rock structures and crevices preventing mussel suffocation and degradation of mudpuppy shelter habitat (Table 2.1, Figure 2.2). Salamander Mussel inhabits rivers and streams with fairly swift velocities. Normal fluctuation in velocity is expected, but extreme changes can be detrimental. A significant and prolonged increase in velocity typically associated with flood conditions has the potential to dislodge mussels and move the bed load (particles that can be transported by flowing water along the stream bed) potentially destroying Salamander Mussel and mudpuppy habitat (Hastie et al. 2001, entire). High shear stress and areas of scour may cause instability of the rock structures themselves, creating unsuitable shelter habitat for Salamander Mussel and mudpuppy. Abnormally high velocities, for example from flood flows, have the potential to displace juveniles and adults, along with washing out free-floating glochidia resulting in mortality. Alternately, Salamander Mussel is a highly mobile and active mussel species with the capability to move to more suitable habitat (Stegman 2020, p. 12). Extreme low flow associated with drought or water withdrawal can impact reproduction, feeding, respiration, and in some cases result in dewatering and exposure and desiccation of the species (USFWS, 2023).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: At a broader scale, suitable Salamander Mussel habitat constitutes stream reaches where mudpuppy is present and there is connectivity between localized populations to allow for mudpuppy and Salamander Mussel dispersal. Connectivity is characterized by suitable water quality, lack of barriers to dispersal (for example, perched culverts, hydropower dams, water control structures etc.), and presence of suitable shelter habitat and forage base for mudpuppies. Having multiple occupied sites within a high degree of habitat connectivity can provide a source of resiliency and redundancy that can benefit the viability of the Salamander Mussel. However, impoundments and other barriers to mudpuppy dispersal, such as river reaches with unsuitable water quality (for example, high concentrations of pollutants or temperature), effectively isolate populations from one another, making repopulation of extirpated locations from nearby populations unlikely without human intervention (in other words, active restocking) (USFWS, 2023)

Population Information and Trends

Number of Populations:

66 currently occupied (USFWS, 2023)

Population Narrative:

Of the 110 known populations of Salamander Mussel, 66 are currently occupied and 44 populations (40%) are either extirpated or historical. These populations are spread across the representation units unevenly, and a high percentage (98.5%) of populations are currently at high risk based on our risk factor analysis. Twenty-three current populations of Salamander Mussel are known from a single or couple records indicating an occupied river extent and, therefore, are more susceptible to extirpation from catastrophic events. The Ohio River basin has 35 populations; of these, 27 are at high risk. The Upper Mississippi basin has 17 extant populations, all of which are at high risk. The Great Lakes basin has 8 populations with completed risk analyses, all of which are at high risk (three populations that cross the border with Canada were unable to be fully analyzed). The Arkansas-White-Red basin has one population that is presumed extant and at high risk. The Tennessee basin has two extant populations, both of which are at high risk. With few populations that are all at high risk, the Great Lakes, Tennessee, and Arkansas-White-Red representation units are all at risk of extirpation. Although the Upper Mississippi representation unit has 14 populations, all of them are at high risk, putting the unit at risk of extirpation. The Ohio basin is the only representation unit with populations experiencing moderate risk (USFWS<,2023).

Threats and Stressors

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Sources - Sources of contaminants can include point (for example, wastewater treatment and industrial effluents, targeted lampricide treatment) and non-point (for example, runoff comprised of fertilizer, pesticide, road salts, grease, and oil) sources resulting from urbanization, agriculture, toxic spills, aquatic invasive species treatments, and resource extraction and mining (Gillis 2012, pp. 348–356; Gillis et al. 2014, pp. 134–143; Bringolf et al. 2007a, pp. 2086–2093; Wang et al. 2017, pp. 786–796; Augspurger et al. 2003, pp. 2569–2575). Contaminants in river systems are varied and widespread from past and current releases and will continue into the future with potential new chemicals of concern (for example, PFAS (polyfluoroalkyl substances)); Hazelton et al. 2012, pp. 1611–1620; Woolnough et al. 2020, 1625–1638). For example, in areas with heavy agriculture or urbanization, contaminants are generally more intense and prevalent. Exposure avenues - The complex life history of freshwater mussels, including the existence of multiple early life stages (for example, glochidia, juveniles etc.), has been a challenge in determining the toxicity of contaminants, which depends on the life stage present and concentration of chemicals (Cope et al. 2008, pp. 451–462). Population and individual impacts and response can vary based on the magnitude, proximity to the contaminant source, sensitivity of host species, and mussel life stage exposed. Contaminants impact surface and pore water (water that occurs in the spaces between sediment/ soil particles) chemistry, sediment composition, and host species fitness and survival (Cope et al. 2008, pp. 451–462). All stages of freshwater mussels are directly exposed to contaminants when present in the system. Contaminants have the potential to affect several reproductive early life history processes including sperm viability, female fertility or brooding capabilities, or luring or glochidia release behavior (Cope et al. 2008, 451–462). Free glochidia are exposed through surface water for seconds, days, or weeks, depending on species and water temperature (Cope et al. 2008, p. 453). Partially encysted glochidia may be exposed to contaminants in surface water and when fully

encysted may be exposed to toxicants in the host tissue (Cope et al. 2008, pp. 455–457). Exposure during encystment may influence the ability of glochidia to successfully transform into juveniles (Cope et al. 2008, pp. 457–458). Adults, however, can be exposed over years through surface water, pore water, sediment, and diet.

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Sediment is composed of both organic (biological material) and inorganic (sand, silt, clay) particulate matter formed through various processes including weathering, wind/wave/ice action, and tectonic uplift. Anthropogenic sources of sediment include agriculture (Peacock et al. 2005), logging (Beschta 1978, entire), mining (Seakem Group et al. 1992, p. 17), urbanization (Guy and Ferguson 1963, entire), and hydrological alteration (Hastie et al. 2001, entire). While all streams carry sediment, alterations in landscape may negatively impact aquatic ecosystems if sediment loads are excessive enough to alter channel formation and/or stream productivity, in turn degrading freshwater biota.

Stressor: Water Temperature, Dissolved Oxygen, and Drought
Exposure:
Response:
Consequence:
Narrative: Alteration to the natural thermal regime of mussels is one of the greatest threats freshwater ecosystems face today (Caissie 2006, p. 1389). Within coming years, this threat may be exacerbated due to climate change. In fact, impacts to organisms and ecosystems are already being observed and it is likely several regional changes in climate will occur in coming years including an increase in frequency and intensity of drought and precipitation in some regions (Intergovernmental Panel on Climate Change [IPCC] 2013, p. 177). Increased surface temperatures and decreases in precipitation will likely lead to elevated stream temperature and decreases in flow (Sinokrot and Gulliver 2000, p. 340). Water temperature and flow are key variables in maintaining riverine biota and if altered can strongly impact the distribution and ecology of freshwater mussels (Olden & Naiman 2010, p.87; Vannote & Sweeny 1980, p. 667; Khan et al. 2019, p. 2). Increased water temperature negatively affects mussel physiological processes (for example, protein damage, fluidity of the cellular membrane, and organ function), disrupting energy balance, growth, and reproduction (Ganser et al. 2015). Drought is a major environmental disturbance, especially in small streams. It is likely mussels are highly sensitive to the secondary effects of drought including low dissolved oxygen, low flow, high water temperature, and high biological oxygen demand (Haag and Warren 2008; p. 1165). Low dissolved oxygen is a threat to freshwater mussels and is particularly an issue interstitial (spaces between individual particles) waters (Sparks and Strayer 1998). Low dissolved oxygen can be caused by excess sedimentation, nutrient loading, organic inputs, changes in flow, and higher temperatures (Sparks and Strayer 1998). Low dissolved oxygen can negatively affect mussels' metabolism.

Stressor: Hydrological Regime
Exposure:
Response:
Consequence:

Narrative: The hydrological regime, also known as the river flow or hydrological variation of a river, determines the dynamics of a river system by directing the processes that shape and organize its associated habitats and biotic communities, while in turn it is defined by distinct daily and seasonal patterns and climatic conditions (Zeiringer et al. 2018, pp. 67–69). These physical processes vary among rivers and are directly related to both water flow characteristics and the type and availability of transportable materials (Zeiringer et al. 2018, p. 69). Significant changes in the magnitude and frequency of these flows have critical impacts on biodiversity and ecosystem integrity (Zeiringer et al. 2018, pp. 69–70; Demaria et al. 2016, p. 309), as shifts in the volume and timing of flows can impact the native freshwater species that occupy aquatic habitats rely on predictable flow patterns for important transitions in their life cycles.

Stressor: Connectivity
Exposure:
Response:
Consequence:
Narrative: Artificial barriers within streams and rivers (for example, dams, road crossings, water control structures, etc.) pose a great number of threats to freshwater mussels and are considered one of the primary reasons for their decline (Downing et al, 2010, pp. 155–160; Vaughn and Taylor, 1999, p. 915). Artificial barriers affect freshwater mussels through direct effects (such as water temperature and flow changes and habitat alteration) and indirect effects (such as changes to food base and fishhost availability). Hydroelectric dams and similar water control barriers can create additional stressors by fluctuating flows to abnormal levels on a daily basis or at inappropriate times of year (Poff et al. 1997, pp. 772–774). Abnormally high stream flow can displace juvenile mussels and make it difficult for them to attach to the substrate (Holland-Bartels 1990, pp. 331–332; Layzer & Madison 1995, p. 335). Altered flow can destabilize the substrate, which is a critical requirement for mussel bed stability (Di Maio and Corkum 1995, p. 663). Barriers can also exacerbate the effects of drought, resulting in the stranding of mussels and drying of mussel beds.

Stressor: Invasive Species
Exposure:
Response:
Consequence:
Narrative: Invasion of aquatic habitats within the United States by invasive species is one of the leading threats freshwater ecosystems face with about 42% of endangered and threatened species reported to be significantly affected (NCANSMPC 2015, p. 8–9; Dueñas et al. 2018, p. 3171). When introduced, nonnative species may outcompete (for example, crowd out or replace) native organisms, in turn negatively altering food web and ecosystem dynamics and ultimately severely damaging ecological health (Davis et al. 2000, p. 227). Invasion of non-native species may be due to lack of predation within the new environment and easier adaptation/tolerance to varying environments. Invasive species can impact native species in a multitude of ways including: (1) native species may become a source of food for invasive species; (2) invasive species may cause or carry diseases; (3) invasive species may prevent native species from reproducing and/or kill native species young; and (4) invasive species may outcompete native species for resources (for example, food, space; Sodhi et al. 2010, p. 318). The invasion of freshwater habitats within the United States has resulted in an imminent threat to mussel fauna within affected regions and thought to have contributed to the decline of mussel species (Ricciardi et al. 1998, p. 615). Invasive species with detrimental effects to freshwater mussels

include Zebra Mussel, Corbicula (freshwater clam), Black Carp, Rusty Crayfish, Spiny Waterflea, Brown Trout, Quagga Mussel, Common Carp, and Bighead Carp. While invasive species do pose a risk to Salamander Mussel, given their unique anatomy, habitat they occupy, and use of a non-fish host, we assessed the risk as either moderate or low. We do not feel there is a plausible situation in which invasive species would pose a risk for probability of persistence to be less than 60%. See Appendix B, C, and Table 4.4, for more information on each of these species and risk posed to Salamander Mussel.

Stressor: Mussel Disease
Exposure:
Response:
Consequence:
Narrative: Enigmatic declines and large-scale die-offs of mussel assemblages within otherwise healthy streams across large geographic regions have emerged as a very concerning risk factor (Haag and Williams 2014, pp. 45–60; Haag 2019, pp. 43–60; Waller and Cope 2019, pp. 26–42). Die-offs have been observed in Europe as well as both the western and eastern U.S. (Waller and Cope 2019, p. 27). In some cases (for example, Clinch River), dies-offs have occurred several years in a row. The mysterious documented decline in mussel populations in the U.S. between the 1970s and 1990s could be the result of a widespread virus, bacteria, fungi, parasite, or a suite of diseases affecting only freshwater mussels (Haag and Williams 2014, pp. 44–46; Haag 2019, pp. 44–45; Waller and Cope 2019, p. 26). More recently, unexplained mussel die-offs have been documented in the eastern U.S. in the Ohio and Tennessee River basins in the Clinch River and Big Darby Creek (Richard et al. 2020, p. 1–10; Waller and Cope 2019, p. 27). The die-off in Big Darby Creek affected all mussel species (Waller and Cope 2019, p. 27). In the Clinch River, the first die-off in 2016 affected only Pheasantshell (Actinonaias pectorosa) though die-offs in 2017, 2018, and 2019, impacted a wider variety of species and additional sites (Waller and Cope 2019, pp. 27–28).

Stressor: Host Species Vulnerability
Exposure:
Response:
Consequence:
Narrative: Mudpuppies are susceptible to many of the same threats that affect mussels including contaminants, habitat degradation and fragmentation, lack of water quality and quantity, known disease issues or die-offs, and potential overharvest and collection. These threats negatively impact the abundance, distribution, and survival of mudpuppy. The conservation status of mudpuppy varies across the 14 states where the range overlaps with Salamander Mussel. Therefore, it is difficult to determine what effect these activities are having at the mudpuppy's population level. Regardless, the magnitude of these factors has the potential to have a significant localized impact on the abundance and distribution of mudpuppies, thereby directly impacting the health and status of Salamander Mussel. Threats to mudpuppies include disease and die-offs, collection, habitat degradation and fragmentation, contaminants, and climate change. See Appendix B for more information about each of these threats.

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

USFWS. 2023. Species status assessment report for the Salamander Mussel (Simpsonaias ambigua). Version 1.1, May 2023. Michigan Ecological Services Field Office, East Lansing, Michigan.

SPECIES ACCOUNT: *Toxolasma cylindrellus* (Pale lilliput (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Endangered; 6/14/1976; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A small freshwater mussel or bivalve mollusk with a tawny or yellowish-green shell. (NatureServe, 2015)

Taxonomy

In an unpublished study of molecular systematics, Campbell and Harris (2006) found this species to be valid and most closely related to Toxolasma lividus. (NatureServe, 2015)

Historical Range

This is a small stream species restricted to the tributaries of the Tennessee River, but not the Tennessee River proper (USFWS, 1984). One exception is a single record from Swamp Creek, Whitfield County, Georgia (recorded in the late 1800s; likely now extirpated); absent from the upper Tennessee drainage. Ortmann collected specimens he thought were Toxolasma cylindrellus from Little Pigeon River, Sevier County, Tennessee. H. D. Athearn collected specimens from the Sequatchie and Little Sequatchie Rivers in Marion County, Tennessee back in the 1950s (Bogan and Parmalee, 1983; Parmalee and Bogan, 1998). It was found in the Paint Rock River and in Larkin Fork of the Paint Rock River (Bogan and Parmalee, 1983) and in the Estill Fork of the Paint Rock River (McGregor and Shelton, 1995). It has also been found in the Flint River and Indian Creek, Madison County, Alabama and in the Elk River, Franklin County, Tennessee. It was also found in the Duck River from Hickman County upstream to Bedford County, Tennessee (Bogan and Parmalee, 1983; Parmalee and Bogan, 1998). The Duck River population is believed to have been extirpated (Steve Ahlstedt, pers. comm. May, 1995), although Parmalee and Bogan (1998) believe it may still be hanging on. (NatureServe, 2015)

Current Range

Currently it is believed to be extant only in the Paint Rock River Drainage in Jackson County, Alabama and adjacent Franklin Co., Tennessee (Bogan and Parmalee, 1985; Williams et al., 2008). It is found in the mainstem of the Paint Rock River and each of its major tributaries: Larkin Fork, Estill Fork, and Hurricane Creek (McGregor and Shelton, 1995) (Doug Shelton, pers. obs., 1996). The largest population was found in the Estill Fork from the Tennessee state line downstream for about one mile (Shelton, 1997) but its viability is now questionable. (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Water is siphoned during feeding and respiration (USFWS, 1984).

Reproduction Narrative

Adult: The glochidial host is not known (NatureServe, 2015). This species is a long-term brooder and is gravid from late summer or autumn into the following summer (Williams et al. 2008). Although the host is unknown, Paul Johnson (pers. comm. 2011) has had limited success with the bluegill sunfish (Lepomis macrochirus) in transforming juveniles (P. Johnson unpublished data, T. Fobian unpublished data) (USFWS, 2011). Freshwater mussels live up to 50 years or more (USFWS, 1984).

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This species is buried in firm rubble, gravel, and sand substrates in shallow riffles and shoals. It is a small stream species restricted to Tennessee River tributaries most often in clean, fast-flowing water in riffle areas in substrates that contain relatively firm rubble, gravel, and sand substrates swept free from siltation (USFWS, 1984). It is sometimes found in sand among aquatic grasses along the shoreline (Doug Shelton - personal observation, 1995). The environmental specificity of this species is narrow and it is highly vulnerable to extinction. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Adult freshwater mussels are largely sedentary spending their entire lives very near to the place where they first successfully settled (Coker et al., 1921; Watters, 1992). Dispersal patterns are largely speculative but have been attributed to stream size and surface geology (Strayer, 1983; Strayer and Ralley, 1993; van der Schalie, 1938), utilization of flow refuges during flood stages (Strayer, 1999), and patterns of host fish distribution during spawning periods (Haag and Warren, 1998; Watters, 1992). Lee and DeAngelis (1997) modeled the dispersal of freshwater into unoccupied habitats as a traveling wave front with a velocity ranging from 0.87 to 2.47 km/year (depending on mussel life span) with increase in glochidial attachment rate to fish having no effect on wave velocity (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of >90% (NatureServe, 2015)

Species Trends:

Unknown (USFWS, 2011)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

The low numbers of individuals and the few populations of this species render it especially vulnerable to extinction. This species possibly occurred historically in a Mobile Basin stream in northwest Georgia (it was known from Swamp Creek in Whitfield Co. in the late 1800s) although it is believed extirpated in that state (J. Wisniewski, GA NHP, pers. comm., January 2007). In Alabama, it was previously endemic to the middle reaches of the Tennessee River system (a few mainstem records but most from tributaries) across much of northern Alabama, but is now extirpated except for the Paint Rock River population (Mirarchi, 2004; Williams et al., 2008). This species has experienced a long-term decline of >90%. The range extent is less than 40 square miles, with an estimated population size of up to 1,000 individuals. There are 1 - 5 occurrences, with none having good viability/integrity (NatureServe, 2015). The species status is uncertain, based on the 2010 Recovery Data Call (USFWS, 2011).

Threats and Stressors

Stressor: Habitat alteration and destruction (NatureServe, 2015)

Exposure:
Response:
Consequence:
Narrative: Globally, threats to this species include alteration and destruction of stream habitat (due to impoundment for flood control, navigation, hydroelectric power, and recreation), siltation (due to strip mining, coal-washing, dredging, farming, logging, and road construction), pollution (caused by municipal, agricultural, and industrial waste discharges) (USFWS, 1984). Silviculture upstream of this site in Franklin County, Tennessee may also threaten his population. (Doug Shelton - personal observation, 1995). Other sites within the drainage may be threatened by poor agricultural practices (Ahlstedt, 1991) and poor silvicultural practices (Doug Shelton - personal observation, 1995) (NatureServe, 2015).

Stressor: Off-road vehicle use (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Regionally, the most imminent threat to the largest population is the practice of the locals to ride four-wheel recreational vehicles in the stream. This has occurred with some regularity at the site in recent years. The reluctance of state and federal authorities to intervene may well jeopardize this last viable population (NatureServe, 2015)

Stressor: Stochastic events (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Natural factors, such as drought, can potentially threaten the continued existence of the pale lilliput. Natural droughts can potentially have negative impacts on water quality (e.g., dissolved oxygen) and waste dissemination of point source discharges. Droughts may also reduce the amount of habitat available to mussels by dewatering habitat, and may also lead to direct mortality by stranding mussels. Drought may also fragment sections of stream into isolated pools. However, in some cases, droughts can also concentrate host fish and therefore, increase the probability of glochidia (larval mussel) to host contact. Human-induced random events such as toxic spills could also jeopardize the pale lilliput if pollutants are spilled within the drainage since the range of the pale lilliput is already reduced to two creeks (Estill Fork and Hurricane Creek). A kill associated with a major spill in the upper tributaries could potentially reduce the occupied range by half. A kill in occupied habitat of any magnitude would have impact due to the small population size (USFWS, 2011).

Stressor: Fish barriers (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Fish barriers, such as those caused by poorly designed road crossings, can limit fish movement as well as distribution of freshwater mussels. In 2010, the Service assessed over 51 river miles in the PRR basin and identified five high priority road crossings that likely function as fish barriers (B. Bouthillier, pers. comm. 2011). Three of these crossings were at locations known to support the pale lilliput, and therefore, possibly limiting its distribution. These barriers may also impact instream and riparian habitat by altering flow direction and velocity, leading to scour

holes and bank collapse (D. Fears pers. comm. 2011) (USFWS, 2011).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. A viable population1 of Toxolasma cylindrellus exists in the Paint Rock River, Estill Fork, and Hurricane Creek. These three populations are dispersed throughout each river so that it is unlikely that any one event would cause the total loss of either population (USFWS, 2011).

2. Through reestablishments and/or discoveries of new populations, viable populations exist in two additional rivers. Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate T. cylindrellus from the river system (USFWS, 2011).

3. The species and its habitat are protected from present and foreseeable human-related natural threats that may interfere with the survival of any of the populations (USFWS, 2011).

4. Noticeable improvements are made in substrate quality with regard to siltation from agricultural land use practices in the Paint Rock River watershed (USFWs, 2011).

Recovery Actions:
- Preserve populations and presently used habitat with emphasis on the Paint Rock River, Estill Fork, and Hurricane Creek (USFWS, 1984).
- Determine the feasibility of introducing the species back into rivers within its historic range and introduce where feasible (USFWS, 1984).
- Conduct life history studies not covered under section 1.2.2, i.e., fish hosts, age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics (USFWS, 1984).
- Determine the number of individuals required to maintain a viable population (USFWS, 1984).
- Investigate the necessity for habitat improvement and, if feasible and desirable, identify techniques and sites for improvement to include implementation (USFWS, 1984).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations (USFWS, 1984).
- Assess overall success of recovery program and recommend action (delist, continued protection, implement new measures, other studies, etc.) (USFWS, 1984).
- Continue working with local landowners to preserve the integrity of stream banks and the riparian zone, and address problem areas by utilizing cost-shares and other conservation initiatives (USFWS, 2011).
- Conduct systematic population monitoring of extant and reintroduced populations (if a reintroduction is achieved) including the documentation of potential threats (USFWS, 2011).
- Specific life history and habitat needs have not been well documented; examine unknown components of life history and ecology, especially as it relates to host fish identification

(USFWS, 2011).

- Update the recovery plan for the species with best available information and to include the importance of propagation/culture, enhancing our knowledge of basic biological processes (host fish identification, life history), and identify reintroduction as a primary recovery objective (USFWS, 2011).
- Develop a contingency plan to respond to a spill or natural disaster within occupied habitat (USFWS, 2011).
- Provide public outreach and education for the pale lilliput, targeting property owners and farmers along the extant range (USFWS, 2011).
- Continue to develop new partnerships and utilize conservation initiatives with landowners along the riparian habitats and within the recharge zone of the PRR drainage basin (USFWS, 2011).
- Conduct genetic and histology research to support fitness of propagation and culture work (USFWS, 2011).
- Conduct a detailed analysis of habitat requirements, including physiochemical parameters of the stream habitat used by the pale lilliput (USFWS, 2011).
- Encourage EPA and ADEM to develop water quality criteria for pollutants based on responses of native mollusk species, including the pale lilliput (USFWS, 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS • Continue working with local landowners adjacent to streams in the upper Paint Rock River watershed in AL and TN, Elk River, Giles, TN; Bear Creek, Colbert County, AL; Big Rock Creek, Marshall County, TN; and Lick Creek, Williamson County, TN to preserve the integrity of stream banks and the riparian zone, and address problem areas by utilizing cost-shares and other conservation initiatives. • Conduct systematic population monitoring of extant and reintroduced populations including the documentation of potential threats. • Conducts surveys in historically occupied watersheds and throughout currently occupied watershed to locate other extant populations and identify suitable release sites. • Continue working with the AABC and CRAC to enhance propagation activities and to examine unknown components of life history and ecology. • Update the recovery plan for the species with best available information and to include the importance of propagation/culture, enhancing our knowledge of basic biological processes, and identify reintroduction as a primary recovery objective. • Develop a contingency plan to respond to a spill or natural disaster within occupied habitat. • Provide public outreach and education for the pale lilliput, targeting property owners and farmers along the extant range. • Continue to develop new partnerships and utilize conservation initiatives with landowners along the riparian habitats and within the recharge zone of the PRR and Duck River drainage basins. • Conduct genetic and histology research to support fitness of propagation and culture work. • Conduct a detailed analysis of habitat requirements, including physiochemical parameters of the stream habitat used by the pale lilliput. • Encourage EPA, ADEM, and TDEC to develop water quality criteria for pollutants based on responses of native mollusk species, including the pale lilliput. (USFWS, 2020)

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2011. Pale Lilliput (Toxolasma cylindrellus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Alabama Ecological Services Field Office Daphne, Alabama

USFWS 1984. Pale Lilliput Pearly Mussel Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 46 pp.

USFWS 2011. Pale Lilliput (Toxolasma cylindrellus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Alabama Ecological Services Field Office Daphne, Alabama.

USFWS. 2011. Pale Lilliput (Toxolasma cylindrellus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Alabama Ecological Services Field Office Daphne, Alabama.

USFWS 2011. Pale Lilliput (Toxolasma cylindrellus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Alabama Ecological Services Field Office, Daphne, Alabama.

USFWS. 2020. Pale Lilliput (Toxolasma cylindrellus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic – Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 27 pp.

SPECIES ACCOUNT: *Truncilla cognata* (Mexican fawnsfoot)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

The Mexican Fawnsfoot is a small-sized freshwater mussel with a yellow to green periostracum and faint chevron-like markings, an elongate outline, and laterally inflated shell (USFWS, 2023)

Taxonomy

The Mexican Fawnsfoot was described as Unio cognatus by Lea (1860, p. 306), from the Rio Salado, in Mexico. The species was moved to the subgenus Amygdalonaias by Simpson (1900, p. 604) and then placed in the genus Truncilla by Frierson (1927, p. 89). Johnson (1999, pp. 39-40) synonymized Truncilla cognata as Truncilla donaciformis due to morphological similarities, and the holotype was a heavily weathered single valve. However, Mexican Fawnsfoot is currently classified in the unionid subfamily Ambleminae (Williams et al. 2017, p. 35) and is considered a valid taxon (Turgeon et al. 1998, p. 33; Williams et al. 2017, p. 44; Burlakova et al. 2019, entire; Smith et al. 2019a, p. 7). The recognized scientific name for Mexican Fawnsfoot is Truncilla cognata, and this report refers to it as such. The following taxonomic treatment follows Williams et al. (2017, p. 44). Phylum: Mollusca Class: Bivalvia Order: Unionoida Family: Unionidae Subfamily: Ambleminae Species: Truncilla cognata (USFWS, 2023)

Historical Range

The Mexican Fawnsfoot is native to the Rio Grande drainage in Texas and northern Mexico (Figure 3.3). Mexican Fawnsfoot occurred historically in the Rio Grande from approximately the confluence of the Pecos River with the Rio Grande (Val Verde County, Texas) to just downstream of Falcon Dam (Starr County, Texas). This represents approximately 340 rmi (541 rkm) of historically occupied river. Presumably, the Mexican Fawnsfoot may have occupied the lower section (approximately one mile) of the Pecos River (Metcalf 1982, p. 52); however, inundation by Lake Amistad in the late 1960s likely extirpated that population. Based on species descriptions (Lea 1860; Johnson 1999, pp. 38-40, 64), we assume the lower Rio Salado was historically occupied by the Mexican Fawnsfoot in the Mexican State of Nuevo León in the lower 48 rmi (77 rkm) before its confluence with the Rio Grande. However, the exact collection location of the holotype is unknown. The Don Martin dam project in Coahuila would have likely extirpated or fragmented any historical populations further upstream in the Rio Salado basin. No other known records exist for Mexican Fawnsfoot from other tributaries to the Rio Grande on the Texas or Mexico sides. As such, we believe the historical range, as described above, is accurate. (USFWS, 2023).

Current Range

Currently, only a single remaining population of Mexican Fawnsfoot is known between the vicinities of Eagle Pass and Laredo, Texas (USFWS, 2023).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Food Source

Adult: Phytoplankton and detritus (USFWS, 2023)

Food/Nutrient Narrative

Adult: Little is known about the specific feeding habits of the Mexican Fawnsfoot, but like the Salina Mucket, it is a filter feeder, siphoning suspended phytoplankton and detritus from the water column (USFWS, 2023)

Lifespan

Adult: assume the species maximum life span is < 18 years (USFWS, 2023)

Dependency on Other Individuals or Species

Adult: Freshwater drum likely host fish (USFWS, 2023)

Reproduction Narrative

Adult: Mussels in the genus Truncilla have miniaturized glochidia and use molluscivorous Freshwater Drum as hosts (Barnhart et al 2008, p. 373 and Smith et al. 2019a, p. 6). The primary host fishes for the Mexican Fawnsfoot are unknown; however, based on other Truncilla spp., they are likely Freshwater Drum (Aplodinotus grunniens)specialists (Haag 2012, p. 178-179; Sietman et al. 2018, p. 1-2; Smith et al. 2019a, p. 6). To date, no empirical laboratory studies have tested host fishes for the Mexican Fawnsfoot. For the purpose of this report, we assume Freshwater Drum serve as a suitable host fish. The reproductive strategy (e.g. mantle lures or conglutinates) is also unknown for the Mexican Fawnsfoot. Some researchers have postulated that some female mussels of the genus Truncilla allow themselves to be preyed (female self-sacrifice) upon by Freshwater Drum to infest the host fish (Haag 2012, p. 178-179). However, this fails to explain the reproductive strategy of larger females that exceed the size range capable of being ingested by Freshwater Drum, or other potential host fish species. Therefore, it is possible that secondary reproductive strategies, such as broadcast of free glochidia or cryptic lures may be the primary method of glochidia dispersal (Haag 2012, p. 179). Species in the genus Truncilla from the Southeastern United States have been reported to reach a maximum life span of 8-18 years (Haag and Rypel 2010, pp. 4-6; Sietman et al. 2018, p. 1). Longevity is unknown for the Mexican Fawnsfoot; however, for the purpose of this report we assume the species maximum life span is < 18 years. (USFWS, 2023).

Habitat Type

Adult: medium to large rivers (USFWS, 2023)

Habitat Narrative

Adult: Adult Mexican Fawnsfoot occur in medium to large rivers, in or adjacent to riffle and run habitats as well as in stream bank habitats (Table 2.2) (Karatayev et al. 2012, p. 211; Brewster 2015, p. 20- 21; Randklev et al. 2017, pp. 221, 223, 234; Randklev et al. 2020b, entire). Small-grained material, such as clay, silt or sand, gathers in these crevices and provides suitable anchoring substrate. These areas are considered flow refuges from the large flood events that occur regularly in the river this species occupies. Mexican Fawnsfoot are able to use flow refuges to avoid being swept away as large volumes of water move through the system, as there is relatively little particle movement in the flow refuges, even during flooding (Strayer 1999, p. 472). However, these areas are topographic high points in a river system and are subject to exposure at reduced flow rates before the stream completely ceases to flow (Brewster 2015, p. 22). Mexican Fawnsfoot are not known to occur in lakes, ponds, or reservoirs (USFWS, 2023).

Dispersal/Migration

Dispersal

Adult: Dispersal by host fish

Population Information and Trends

Population Trends:

Presumed extirpated

Number of Populations:

One (USFWS, 2023)

Population Narrative:

Currently, only a single remaining population of Mexican Fawnsfoot is known between the vicinities of Eagle Pass and Laredo, Texas (USFWS, 2023)

Threats and Stressors

Stressor: Increased Fine Sediment
Exposure:
Response:
Consequence:
Narrative: Freshwater mussels require specific stream substrates (e.g. silt, sand, gravel, and larger cobbles) in order to anchor themselves into place in the streambed. Interstitial spaces (small openings between rocks and gravels) in the substrate provide essential habitat for juvenile mussels. Juvenile freshwater mussels burrow into interstitial substrates, making them particularly susceptible to degradation of this habitat feature. When clogged with sand or silt, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability and survivorship. Excessive fine sediments can also embed larger crevices; potentially causing a change in overall substrate composition and even leading to smothering of adult or juvenile mussels that occupy those spaces.

Stressor: Water Quality Impairment
Exposure:
Response:
Consequence:
Narrative: Water quality can be impaired through contamination or by alteration of naturally occurring water chemistry. Chemical contaminants are ubiquitous throughout the environment and are a major reason for the current declining status of freshwater mussel species nationwide (Augspurger et al. 2007, p. 2025). Chemicals enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal effluents, and agricultural runoff. These sources contribute organic compounds, heavy metals, pesticides, herbicides, and a

wide variety of newly emerging contaminants to the aquatic environment. Ammonia is of particular concern downstream of agricultural areas and water treatment plant outfalls as freshwater mussels have been shown particularly sensitive to increased ammonia levels at multiple life stages (Augspurger et al. 2003, p. 2569). It is likely for this reason that Mexican Fawnsfoot are not found for many miles downstream of multiple wastewater treatment plants that discharge into the Rio Grande from both the U.S. and Mexico near Nuevo Laredo.

Stressor: Loss of Flowing Water
Exposure:
Response:
Consequence:
Narrative: The Rio Grande mussels need flowing water to survive. Low flow events (including stream drying) severe flooding, and inundation are all forms of hydrologic alteration that can eliminate appropriate habitat conditions for both species, and while the species may survive these events if they last for a short time, populations that experience these conditions frequently or continuously will not persist (Figure 5.3). Inundation has primarily occurred in the Rio Grande basin upstream of dams, both large (e.g. Amistad and Falcon) and small (e.g. water weirs, diversion dams, such as those in the Rio Grande below Amistad). Inundation causes an increase in sediment deposition, eliminating interstitial spaces both mussel species need to anchor themselves and for juvenile growth. Inundation may also alter water quality (see section 5.2, Water Quality Impairment). Very low water levels are detrimental to the Rio Grande mussels, as well.

Stressor: Barriers to Fish Movement
Exposure:
Response:
Consequence:
Narrative: The natural ranges of the Rio Grande mussels historically extended throughout the mainstem Rio Grande and select major tributaries in Texas (see Chapter 3 Populations and Species Needs, for a more in-depth description). The overall distribution of mussels is, in part, a function of the dispersal of their host fish. Mussels colonize new areas through movement of infested host fish, and newly metamorphosed juveniles excysting from host fish into suitable habitats in new locations. Today, each species has only a single remaining population with an uneven distribution within the larger population. This range restriction has greatly reduced the species ability to recolonize new areas, expand its current range, or maintain more distant mussel beds through fish host movement. The construction and operation of large and small impoundments also limits potential for immigration and emigration among populations. At the species level, populations that are eliminated due to stochastic events cannot be recolonized naturally, leading to reduced overall redundancy and representation. The Rio Grande mussels have no redundant populations to serve as sources to restore populations eliminated due to stochastic events.

Stressor: Increased Predation
Exposure:
Response:
Consequence:
Narrative: Predation on freshwater mussels is a natural ecological interaction. Raccoons, snapping turtles, and fish are known to prey upon multiple mussel species including the Rio

Grande mussels. Under natural conditions, the level of predation occurring is not likely to pose a significant risk to any given population. However, during periods of low flow, terrestrial predators have increased access to portions of the river that are otherwise too deep and inaccessible under normal flow conditions. As drought and low flow are projected to occur more often and for longer periods due to the anticipated effects of future climate change (Figure 5.4), we expect predation will become a more significant risk. Further, because each species only has one extant population, the otherwise natural levels of predation could be much more detrimental to the species. However, at this time, predation on the Salina Mucket has not been observed at levels that would indicate it will have a detrimental impact on the long-term viability of the species. Therefore, we are not carrying this stressor forward in the future analysis for Salina Mucket. Conversely, the Mexican Fawnsfoot occupies primarily riffle habitats, which are topographic high points in a stream system. These areas are relatively shallow even under normal flow conditions and are prone to partial dewatering or desiccation during drought events. Reductions in water levels would put the Mexican Fawnsfoot at an increased risked of predation from terrestrial predators. Therefore, we are carrying this stressor forward in future analysis for Mexican Fawnsfoot.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Climate change has begun, and continued greenhouse gas emissions at or above current rates will cause further warming (Intergovernmental Panel on Climate Change (IPCC) 2013, pp. 11–12). Warming in the Southwest is expected to be greatest in the summer (IPCC 2013, pp. 11–12), and annual mean precipitation is very likely to decrease in the Southwest (IPCC 2013, pp. 11–12; Ray et al. 2008, p. 1). In Texas, the number of extreme hot days (high temperatures exceeding 95º Fahrenheit) are expected to double by around 2050 (Kinniburgh et al. 2015, p. 83). Texas is considered one of the “hotspots” of climate change in North America with West Texas highlighted as an area that is expected to show greater responsiveness to the effects of climate change (Diffenbaugh et al. 2008, p. 3). Even if precipitation and groundwater recharge remain at current levels, increased groundwater pumping and resultant aquifer shortages due to increased temperatures are nearly certain (Loaiciga et al. 2000, p. 193; Mace and Wade 2008, pp. 662, 664- 665; Taylor et al. 2012, p. 3). Climate change effects, such as air temperature increases and an increase in drought frequency and intensity, have been occurring throughout the ranges of the Rio Grande mussels (Kinniburgh et al. 2015, p. 88). These effects are expected to exacerbate several of the stressors discussed above, such as water temperature and loss of flowing water (Wuebbles et al. 2013, p. 16). In our analysis of the future condition of the Rio Grande mussels, we considered climate change to be an exacerbating factor in the increase of fine sediments, changes in water quality, loss of flowing water, and predation.

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

USFWS. 2023. Species Status Assessment Report for two Rio Grande Mussels, Version 1.2. February 2023. Albuquerque, NM.

SPECIES ACCOUNT: *Truncilla macrodon* (Texas fawnsfoot)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Texas fawnsfoot is a small, relatively thin-shelled freshwater mussel that can reach 60 mm (2.4 in) in length but is usually much smaller (Howells 2010d, p. 2). The shell is long and oval, generally free of external sculpturing, with external coloration that varies from yellowish- or orangish-tan, brown, reddish-brown, to smokygreen with a pattern of broken rays or irregular blotches (Howells 2010d, p. 2). The nacre (inside of the shell) is bluish-white or white and iridescent posteriorly (Howells 2010d, p. 2).

Taxonomy

The Texas fawnsfoot was first described as Unio macrodon by Lea in 1859 and was subsequently placed in the genus Margaron by Lea in 1870 and then moved to Plagiola by Simpson (1900, p. 605). Ultimately the species was placed in the genus Truncilla by Strecker (1931, pp. 63, 65). The Texas fawnsfoot is recognized by the Committee on Scientific and Vernacular Names of Mollusks of the Council of Systematic Malacologists, American Malacological Union (Turgeon et al. 1998, p. 37), and we recognize it as a valid species.

Historical Range

The Texas fawnsfoot is endemic to the Brazos and Colorado Rivers of central Texas (Howells et al. 1996, p. 143; Randklev et al. 2010a, p. 297). From the 1960s to the 1990s, malacologists working in central Texas found few individuals and few new population locations (Howells 2010d, p. 6). Historical records suggest the Texas fawnsfoot inhabited much of the Colorado River, from Wharton County upstream as far as the North Fork Concho River in Sterling County, as well as throughout the Concho, San Saba, and Llano Rivers and Onion Creek within the Colorado River basin (Howells 2010d, p. 4; Randklev et al. 2010b, p. 24). In the Brazos River, the species occurred from Fort Bend County upstream to the lower reaches of the Clear Fork Brazos River in Shackelford County, as well as in the Leon River, Little River, San Gabriel River, Deer Creek, and Yegua Creek (Howells 2010d, pp. 45; Randklev et al. 2010b, p. 24). Species reports from the Trinity River and other east Texas locations are of misidentified fawnsfoot (Truncilla donaciformis) (Howells 2010d, p. 4).

Current Range

Texas fawnsfoot occurs in the lower reaches of the Colorado and Brazos Rivers, (Randklev et al. 2017, p. 4), as well as in the main stem of the Trinity River (Figure 5.5). Among these three basins, Texas fawnsfoot currently inhabits 659.7 stream miles of a presumed 3,540.5 stream miles, representing 18.7% of its presumed historical distribution. This approximate range reduction assumes the species continuously occupied its entire historical range, which is unlikely given the species' specialized habitat preferences. (USFWS, 2019)

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 7/5/2024.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli), and threatened species status for the Texas fawnsfoot (Truncilla macrodon), seven species of freshwater mussels from central Texas. We also issue a rule under section 4(d) of the Act for the Texas fawnsfoot that provides measures that are necessary and advisable to provide for the conservation of the Texas fawnsfoot. In addition, we designate critical habitat for all seven species. In total, approximately 1,577.5 river miles (2,538.7 river kilometers) in Blanco, Brown, Caldwell, Coleman, Comal, Concho, DeWitt, Gillespie, Gonzales, Guadalupe, Hays, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, Palo Pinto, Parker, Runnels, San Saba, Shackelford, Stephens, Sutton, Throckmorton, Tom Green, Travis, and Victoria Counties, Texas, fall within the boundaries of the critical habitat designation. This rule applies the protections of the Act to these species and their designated critical habitats (89 FR 48034).

Critical Habitat Designation

We have determined that the Guadalupe fatmucket (Lampsilis bergmanni), Texas fatmucket (Lampsilis bracteata), Guadalupe orb (Cyclonaias necki), Texas pimpleback (Cyclonaias (=Quadrula) petrina), Balcones spike (Fusconaia (=Quincuncina) iheringi), and false spike (Fusconaia (=Quincuncina) mitchelli) meet the Act's definition of endangered species, and the Texas fawnsfoot (Truncilla macrodon) meets the Act's definition of a threatened species; therefore, we are listing them as such, finalizing a rule under section 4(d) of the Act for the Texas fawnsfoot, and designating critical habitat. Both listing a species as an endangered or threatened species and designating critical habitat can be completed only by issuing a rule through the Administrative Procedure Act rulemaking process (5 U.S.C. 551 et seq.). What this document does. This rule makes final the listing of the Guadalupe fatmucket, Texas fatmucket, Guadalupe orb, Texas pimpleback, Balcones spike, and false spike as endangered species, and the Texas fawnsfoot as a threatened species with a rule issued under section 4(d) of the Act (a ''4(d) rule''). In addition, this rule designates critical habitat for all seven central Texas mussel species in 20 units (including 32 subunits) totaling 1,577.5 river miles (2,538.7 river kilometers (km)) on private, State, and Federal property within portions of 31 counties in Texas (89 FR, 48034)

Primary Constituent Elements/Physical or Biological Features

(i) Flowing water at moderate to high rates with sufficient depth to remain sufficiently cool and oxygenated during low-flow periods;

(ii) Substrate including bedrock and boulder crevices, point bars, and vegetated run habitat comprising sand, gravel, and larger cobbles

(iii) Green sunfish (Lepomis cyanellus), bluegill (L. macrochirus), largemouth bass (Micropterus salmoides), and Guadalupe bass (M. treculii) present

(iv) Water quality parameters within the following ranges: (A) Dissolved oxygen greater than 2 milligrams per liter (mg/L); (B) Salinity less than 2 parts per thousand; (C) Total ammonia less than 0.77 mg/ L total ammonia nitrogen; (D) Water temperature below 29 °C (84.2 °F); and (E) Low levels of contaminants

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the central Texas mussels may require special management considerations or protections to reduce the following threats: increased fine sediment, changes in water quality, altered hydrology from both inundation and flow loss/scour, predation and collection, and barriers to fish movement. Management activities that could ameliorate these threats include, but are not limited to: Use of best management practices (BMPs) designed to reduce sedimentation, erosion, and bank side destruction; protection of riparian corridors and retention of sufficient canopy cover along banks; exclusion of livestock and nuisance wildlife (feral hogs, exotic ungulates); moderation of surface and groundwater withdrawals to maintain natural flow regimes; increased use of stormwater management and reduction of stormwater flows into the systems; use of highest water quality standards for wastewater and other return flows; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the occupied areas we are designating as critical habitat contain the PBFs that are essential to the conservation of the species and that may require special management considerations or protection. Special management considerations or protection may be required of the Federal action agency to eliminate, or to reduce to negligible levels, the threats affecting the PBFs of each unit (89 FR, 48034)..

Life History

Feeding Narrative

Larvae: Larval unionid mussels require a host (typically a fish).

Juvenile: For their first several months, juvenile mussels feed using cilia (fine hairs) on the foot to capture suspended as well as depositional material, such as algae and detritus (Yeager et al. 1994, pp. 253259). Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity, when energy presumably is being diverted from growth to reproductive activities (Baird 2000, pp. 6667).

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874876; Christian et al. 2004, p. 109).

Reproduction Narrative

Larvae: Most mussel species, including Texas fawnsfoot, have distinct forms of male and female. During reproduction, males release sperm into the water column, which females draw in through their siphons. Fertilization takes place internally, and the resulting eggs develop into specialized larvae (called glochidia) within the females modified gill pouch (called marsupia) for four to six weeks. The females will then release matured glochidia individually, in small groups, or embedded in larger mucus structures called conglutinates. Glochidia are obligate parasites (cannot live independently of their hosts) on fish and attach to the gills or fins of appropriate host species where they encyst (enclose in a cyst-like structure) and feed off of the hosts body fluids (Vaughn and Taylor 1999, p. 913) and develop into juvenile mussels weeks or months after attachment (Arey 1932, pp. 214215). The glochidia will die if they fail to find the appropriate host fish, attach to a fish that has developed immunity from prior infestations, or attach to the wrong location on a host fish (Neves 1991, p. 254; Bogan 1993, p. 299). Mussels experience their primary opportunity for dispersal and movement within the stream as glochidia attached to a host fish (Smith 1985, p. 105). Upon release from the host, newly transformed juveniles drop to the substrate on the bottom of the stream. Those juveniles that drop in unsuitable substrates die because their immobility prevents them from relocating to more favorable habitat. Juvenile freshwater mussels burrow into interstitial substrates and grow to a larger size that is less susceptible to predation and displacement from high flow events (Yeager et al. 1994, p. 220). Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish.

Adult: There is no specific information on age, size of maturity, or host fish use for Texas fawnsfoot. However, other species in the genus Truncilla parasitize freshwater drum (Aplodinotus grunniens) (OSUM 2011f, p. 1), and it is likely the Texas fawnsfoot does as well. Freshwater drum are ubiquitous throughout the range of Texas fawnsfoot (Hubbs et al. 2008, p. 53). Mussels are extremely long lived, living from two to several decades (Rogers et al. 2001, p. 592), and possibly up to 200 years in extreme instances (Bauer 1992, p. 427).

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Since Texas fawnsfoot were not found alive for many years, very little information is available about its habitat preferences. In the past only Texas fawnsfoot shells and recently dead individuals were occasionally found along rivers following drought-related dewatering or bank deposition after high floods. These shells and recently dead individuals indicated that the Texas fawnsfoot occurs in flowing water, as it was never found in ponds, lakes, or reservoirs, suggesting that it is intolerant of deep, low-velocity waters created by artificial impoundments (Howells 2010d, p. 3). The recently discovered live population in the Brazos River indicates that the species occurs in rivers with soft, sandy sediment with moderate water flow (Randklev and Lundeen 2010, p. 1; Randklev et al. 2010a, p. 298; Johnson 2011, p. 1).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Immigration/Emigration

Larvae: not likely because of fragmented habitat

Juvenile: not likely because of fragmented habitat

Adult: not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Mostly declining and a few are stable

Species Trends:

Declining

Resiliency:

The Texas fawnsfoot is known to occur in three river basins: the Trinity, Brazos, and Colorado. The species has a total of seven populations spread across these three basins. In the Trinity River basin, two populations are currently isolated from one another and are in moderately healthy condition. The Trinity River populations both exhibit low resiliency. The Brazos River contains three populations of Texas fawnsfoot: the Clear Fork Brazos, upper Brazos, and lower Brazos River populations. Prior to dam construction, these populations were likely all once connected, but now they are isolated from one another. Two of the populations are in unhealthy condition and one is moderately healthy. The Colorado basin contains two isolated populations of Texas fawnsfoot. The lower Colorado population is currently moderately healthy and has a relatively large geographic area. The San Saba River population is unhealthy and therefore has low resiliency. (USFWS, 2019)

Representation:

We consider the Texas fawnsfoot to have representation in each of three river basins: the Trinity, Brazos, and Colorado River basins (Figure 5.6) (USFWS, 2019)

Redundancy:

Within these identified representation areas, Texas fawnsfoot is known from two populations in the Trinity River basin, three in the Brazos River basin, and two in the Colorado River basin. (USFWS, 2019)

Population Growth Rate:
unknown

Number of Populations:
7

Population Size:
unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Based on historical and current data, the Texas fawnsfoot has declined rangewide and is now known from only seven populations. The species has been extirpated from nearly all of the Colorado River basin and from much of the Brazos River basin. Of the populations that remain, only the lower Colorado, San Saba, and Brazos River populations are likely to be stable and recruiting; the remaining populations are disjunct and restricted to short stream reaches.

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: A major factor in the decline of freshwater mussels across the United States has been the large-scale impoundment of rivers (Vaughn and Taylor 1999, p. 913). Dams are the source of numerous threats to freshwater mussels: They block upstream and downstream movement of species by blocking host fish movement; they eliminate or reduce river flow within impounded areas, thereby trapping silts and causing sediment deposition; and dams change downstream water flow timing and temperature, decrease habitat heterogeneity, and affect normal flood patterns (Layzer et al. 1993, pp. 6869; Neves et al. 1997, pp. 6364; Watters 2000, pp. 261264; Watters 1996, p. 80). Within reservoirs (the impounded waters behind dams), the decline of freshwater mussels has been attributed to sedimentation, decreased dissolved oxygen, and alteration of resident fish populations (Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 261264). Dams significantly alter downstream water quality and stream habitats (Allan and Flecker 1993, p. 36; Collier et al. 1996, pp. 1, 7) resulting in negative effects to tailwater (the area downstream of a dam) mussel populations (Layzer et al. 1993, p. 69;

Neves et al. 1997, p. 63; Watters 2000, pp. 265266). Below dams, mussel declines are associated with changes and fluctuation in flow regime, scouring and erosion of stream channels, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Williams et al. 1992, p. 7; Layzer et al. 1993, p. 69; Neves et al. 1997, pp. 6364; Pringle et al. 2000, pp. 810815; Watters 2000, pp. 265266). Numerous dams have been constructed throughout the Colorado and Brazos River systems within the range of Texas fawnsfoot (Stanley et al. 1990, p. 61). Population losses due to the effects of dams and impoundments have likely contributed more to the loss of diversity and abundance of freshwater mussels across Texas, including the Texas fawnsfoot, than any other factor. Stream habitat throughout nearly all of the range of Texas fawnsfoot has been affected by numerous impoundments, leaving generally short, isolated patches of remnant habitat between dams. Impoundments have resulted in profound changes to the nature of the rivers, primarily replacing free-flowing river systems with a series of large reservoirs.

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Siltation and general sediment runoff is a pervasive problem in streams and has been implicated in the decline of stream mussel populations (Ellis 1936, pp. 3940; Vannote and Minshall 1982, p. 4105; Dennis 1984, p. ii; Brim Box and Mossa 1999, p. 99; Fraley and Ahlstedt 2000, pp. 193194). Specific biological effects on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills (Ellis 1936, p. 40), disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity (Marking and Bills 1979, pp. 208209; Vannote and Minshall 1982, p. 4106), physical smothering, and disrupted host fish attractant mechanisms (Hartfield and Hartfield 1996, p. 373). The primary effects of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999, p. 101). The physical effects of sediment on mussel habitats are multifold and include changes in suspended material load; changes in streambed sediment composition from increased sediment production and runoff in the watershed; changes in the form, position, and stability of stream channels; changes in water depth or the width-to-depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave mussels stranded (Brim Box and Mossa 1999, pp. 109112). Increased sedimentation and siltation may explain, in part, why Texas fawnsfoot appear to be experiencing recruitment failure in some streams. Interstitial spaces (small openings between rocks and gravels) in the substrate provide essential habitat for juvenile mussels. When clogged with sand or silt, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability. Juvenile freshwater mussels, including Texas fawnsfoot juveniles, burrow into interstitial substrates, making it particularly susceptible to degradation of this habitat.

Stressor: Dewatering
Exposure:
Response:
Consequence:
Narrative: River dewatering can occur in several ways: anthropogenic activities such as surface water diversions and groundwater pumping, and natural events, such as drought. Surface water diversions and groundwater pumping can lower water tables, reducing river flows and reservoir

levels. These actions can result in mussels stranded in previously wetted areas. This is a particular concern for Texas fawnsfoot within and below reservoirs, where water levels are managed for various purposes that can cause water levels in the reservoir or downstream to rise or fall in very short periods of time, such as when hydropower facilities release water during peak energy demand periods.

Stressor: Sand and Gravel Mining
Exposure:
Response:
Consequence:
Narrative: Sand and gravel mining (removing bed materials from streams) has been implicated in the destruction of mussel populations across the United States (Hartfield 1993, pp. 136138). Sand and gravel mining causes stream instability by increasing erosion and turbidity (a measure of water clarity) and causing subsequent sediment deposition downstream (Meador and Layher 1998, pp. 89). These changes to the stream can result in large-scale changes to aquatic fauna, by altering habitat and affecting spawning of fish, mussels, and other aquatic species (Kanehl and Lyons 1992, pp. 411).

Stressor: Chemical Contaminants
Exposure:
Response:
Consequence:
Narrative: Chemical contaminants are ubiquitous throughout the environment and are a major reason for the decline of freshwater mussel species nationwide (Richter et. al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007a, p. 2029). Chemicals enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal effluents, and agriculture runoff. These sources contribute organic compounds, heavy metals, pesticides, herbicides, and a wide variety of newly emerging contaminants to the aquatic environment. As a result, water quality can be degraded to the extent that mussel populations are adversely affected.

Stressor: Disease
Exposure:
Response:
Consequence:
Narrative: Little is known about disease in freshwater mussels. However, disease is believed to be a contributing factor in documented mussel die-offs in other parts of the United States (Neves 1987, pp. 1112). Diseases have not been documented or observed during any studies of Texas fawnsfoot.

Stressor: Predation
Exposure:
Response:
Consequence:
Narrative: Raccoons will prey on freshwater mussels stranded by low waters or deposited in shallow water or on bars following flooding or low water periods (Howells 2010c, p. 12). Predation of Texas fawnsfoot by raccoons may be occurring occasionally, but there is no indication it is a significant threat to the status of the species. Some species of fish feed on

mussels, such as common carp, freshwater drum, and redear sunfish, all of which are common throughout the range of Texas fawnsfoot (Hubbs et al. 2008, pp. 19, 45, 53). Common species of flatworms are voracious predators of newly metamorphosed juvenile mussels of many species (Zimmerman et al. 2003, p. 30). Predation is a normal factor influencing the population dynamics of a healthy mussel population; however, predation may amplify declines in small populations primarily caused by other factors.

Stressor: Inadequate regulatory mechanisms
Exposure:
Response:
Consequence:
Narrative: Despite some State and Federal laws protecting the species and water quality, the Texas fawnsfoot continues to decline due to the effects of habitat destruction, poor water quality, contaminants, and other factors. The regulatory measures described above are not sufficient to significantly reduce or remove the threats to the Texas fawnsfoot. Based upon our review of the best commercial and scientific data available, we conclude that the lack of existing regulatory mechanisms is an immediate threat of moderate magnitude to the Texas fawnsfoot.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: It is widely accepted that changes in climate are occurring worldwide (International Panel on Climate Change (IPCC) 2007, p. 30). Understanding the effects of climate change on the Texas fawnsfoot is important because the disjunct nature of the remaining Texas fawnsfoot populations, coupled with the limited ability of mussels to migrate, makes it unlikely that the Texas fawnsfoot can adjust its range in response to changes in climate (Strayer 2008, p. 30). For example, changes in temperature and precipitation can increase the likelihood of flooding or increase drought duration and intensity, resulting in direct effects to freshwater mussels like the Texas fawnsfoot (Hastie et al. 2003, pp. 4043; Golloday et al. 2004, p. 503). Because the range of the Texas fawnsfoot has been reduced to isolated locations with low population numbers in small to medium sized rivers and streams, the Texas fawnsfoot is vulnerable to climatic changes that could decrease the availability of water or produce more frequent scouring flood events. Indirect effects of climate change may include declines in host fish populations, habitat reduction, and changes in human activity in response to climate change (Hastie et al. 2003, pp. 4344).

Stressor: Population Fragmentation and Isolation
Exposure:
Response:
Consequence:
Narrative: As with many freshwater mussels, several of the remaining populations of the Texas fawnsfoot are small and geographically isolated and thus are susceptible to genetic drift, inbreeding depression, and random or chance changes to the environment, such as toxic chemical spills (Watters and Dunn 1995, pp. 257258), or dewatering. Inbreeding depression can result in death, decreased fertility, smaller body size, loss of vigor, reduced fitness, and various chromosomal abnormalities (Smith 1974, pp. 350). Despite any evolutionary adaptations for rarity, habitat loss and degradation increase a species vulnerability to extinction (Noss and

Cooperrider 1994, pp. 5862). Numerous authors (including Noss and Cooperrider 1994, pp. 5862; Thomas 1994, p. 373) have indicated that the probability of extinction increases with decreasing habitat availability. Although changes in the environment may cause populations to fluctuate naturally, small and low-density populations are more likely to fluctuate below a minimum viable population (the minimum or threshold number of individuals needed in a population to persist in a viable state for a given interval) (Gilpin and Soule 1986, pp. 2533; Shaffer 1981, p. 131; Shaffer and Samson 1985, pp. 148150). Historically, the Texas fawnsfoot was widespread throughout much of the Colorado and Brazos River systems when few natural barriers existed to prevent migration (via host species) among suitable habitats. Construction of dams, however, likely destroyed many Texas fawnsfoot populations through drastic habitat changes and isolated the remnant populations from each other. The extensive impoundment of the Brazos and Colorado River basins has fragmented Texas fawnsfoot populations throughout these river systems. For fertilization, Texas fawnsfoot females need an upstream male to release sperm; populations with few individuals reduce the likelihood that females will be exposed to sperm while siphoning. Therefore, recruitment failure is a potential problem for many small populations rangewide, a potential condition exacerbated by its reduced range and increasingly isolated populations. If downward population trends continue, further significant declines in total Texas fawnsfoot population size and consequent reduction in long-term survivability may soon become apparent. Small Texas fawnsfoot populations, including those in the Brazos River, Clear Fork Brazos River, Navasota River, and Deer Creek, may be below the minimum population size required to maintain population viability into the future. These populations are more vulnerable to extirpation since they are less likely to be able to recover through recruitment from events that reduce but do not extirpate populations. Additionally, these small populations are more vulnerable to extirpation from stochastic (random) natural events, as the lack of connectivity among populations does not permit nearby populations to recolonize areas affected by intense droughts, toxic spills, or other isolated events that result in significant mussel die-offs. When species are limited to small, isolated habitats, as the Texas fawnsfoot is, they are more likely to become extinct due to a local event that negatively effects the population (McKinney 1997, p. 497; Minckley and Unmack 2000, pp. 5253; Shepard 1993, pp. 354357). While the populations small, isolated nature does not represent an independent threat to the species, it does substantially increase the risk of extirpation from the effects of all other threats, including those addressed in this analysis, and those that could occur in the future from unknown sources. Based upon our review of the best commercial and scientific data available, we conclude that fragmentation and isolation of small remaining populations of the Texas fawnsfoot are occurring and are ongoing threats to the species throughout all of its range. Further, stochastic events may play a magnified role in extirpation of small, isolated populations.

Stressor: Nonnative Species
Exposure:
Response:
Consequence:
Narrative: Various nonnative species of aquatic organisms are firmly established within the range of the Texas fawnsfoot and pose a threat to the species. Golden algae (Prymnesium parvum) is a microscopic algae considered to be one of the most harmful algal species to fish and other gill-breathing organisms (Lutz-Carrillo et al. 2010, p. 24). Golden algae was first discovered in Texas in 1985 and is presumed to have been introduced from western Europe (Lutz- Carrillo et al. 2010, p. 30). Since its introduction, golden algae has been found in Texas rivers and lakes, including two lakes in central Texas (Baylor University 2009, p. 1). Under certain environmental conditions, this

algae can produce toxins that can cause massive fish and mussel kills (Barkoh and Fries 2010, p. 1; Lutz-Carrillo et al. 2010, p. 24). Evidence shows that golden algae probably caused fish kills in Texas as early as the 1960s, but the first documented fish kill due to golden algae in inland waters of Texas occurred in 1985 on the Pecos River in the Rio Grande basin (TPWD 2002, p. 1). The range of golden algae has increased to include portions of the Brazos and Colorado River basins, among others, and it has been responsible for killing more than 8 million fish in the Brazos River since 1981 and more than 2 million fish in the Colorado River since 1989 (TPWD 2010a, p. 1). Although actual mussel kills in Texas due to golden algae have not been recorded in the past, the toxin can kill mussels. Therefore, the elimination of host fish and the poisonous nature of the toxin to mussels make future golden algae blooms a threat to the Texas fawnsfoot. An additional nonnative species, the zebra mussel (Dreissena polymorpha), poses a potential threat to the Texas fawnsfoot. This invasive species has been responsible for the extirpation of freshwater mussels in other regions of the United States, including the Higgins eye (Lampsilis higginsii) in Wisconsin and Iowa (Service 2006, pp. 910). Zebra mussels attach in large numbers to the shells of live native mussels and are implicated in the loss of entire native mussel beds (Ricciardi et al. 1998, p. 615). This fouling impedes locomotion (both laterally and vertically), interferes with normal valve movements, deforms valve margins, and essentially suffocates and starves the native mussels by depleting the surrounding water of oxygen and food (Strayer 1999, pp. 7780). Heavy infestations of zebra mussels on native mussels may overly stress the animals by reducing their energy reserves. Zebra mussels may also filter the sperm and possibly glochidia of native mussels from the water column, thus reducing reproductive potential. Habitat for native mussels may also be degraded by large deposits of zebra mussel pseudofeces (undigested waste material passed out of the incurrent siphon) (Vaughan 1997, p. 11). Zebra mussels are not currently found within the range of the Texas fawnsfoot. However, a live adult zebra mussel was first documented in Lake Texoma on the Red River (on the north Texas border with Oklahoma) in 2009 (TPWD 2009a, p. 1). Since that time, additional zebra mussels have been reported from Lake Texoma, where they are now believed to be well established (TPWD 2009c, p. 1). New studies looking for the presence of zebra mussel DNA and zebra mussel larvae (veligers) within 14 North Texas reservoirs revealed that zebra mussel DNA was present in six of those reservoirs; however, none of those reservoirs contained veliger larvae, which suggests that zebra mussels have not become established in those lakes (TPWD 2012, p. 1). To date, Lake Texoma is the only reservoir known to harbor zebra mussels from all life stages. Zebra mussels are likely to spread to many other Texas reservoirs through accidental human transport (Schneider et al. 1998, p. 789). Although zebra mussels tend to proliferate in reservoirs or large pools, released zebra mussel veligers float downstream and attach to any hard surface available, rendering downstream Texas fawnsfoot populations extremely vulnerable to attachment and fouling. Because zebra mussels are so easily introduced to new locations, the potential for zebra mussels to continue to expand in Texas and invade the range of the Texas fawnsfoot is high. If this occurs, the Texas fawnsfoot is vulnerable to zebra mussel attachment and subsequent deprivation of oxygen, food, and mobility. A molluscivore (mollusk eater), the black carp (Mylopharyngodon piceus) is a potential threat to the Texas fawnsfoot. The species has been commonly used by aquaculturists to control snails or for research in fish production in several States, including Texas (72 FR 59019, October 18, 2007). Black carp can reach more than 1.3 m (4 ft) in length and 150 pounds (68 kilograms (kg)) (Nico and Williams 1996, p. 6). Foraging rates for a 4-year old fish average 3 to 4 pounds (1.4 to1.8 kg) a day, indicating that a single individual could consume 10 tons (9,072 kg) of native mollusks over its lifetime (Mississippi Interstate Cooperative Resource Association (MICRA) 2005, p. 1). Black carp can escape from aquaculture facilities. For example, in 1994 30 black carp escaped from an aquaculture facility in Missouri during a flood. Other escapes into the wild by non-sterile carp are likely to occur. Because of the high risk to freshwater mussels and other native mollusks, the Service recently listed black carp as an injurious species under the Lacey Act (72 FR 59019, October 18, 2007), which prevents importations and interstate transfer of this harmful species, but does not prevent its release into the wild once it is in the State. If the black carp were to escape within the range of the Texas fawnsfoot, it would likely negatively affect native mussels, including the Texas fawnsfoot. Based upon our review of the best commercial and scientific data available, we conclude that golden algae is an ongoing threat to the Texas fawnsfoot, and other nonnative species, such as zebra mussels and black carp, are a potential future threat to the Texas fawnsfoot that is likely to increase as these exotic species expand their occupancy within the range of the Texas fawnsfoot.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:

- Continued survey and monitoring efforts are needed throughout former and occupied sites to better define the species distribution and status in the Colorado and Brazos River systems.
- Continued biological and ecological research efforts are needed to identify host fish, spawning and brooding seasons, glochidia, and habitat and physiochemical parameters for the Texas fawnsfoot.
- The Service will continue to work with TPWD, USGS, and others needed research in order to facilitate the conservation and preservation of the Texas fawnsfoot.
- Long-term conservation measures need to be developed to facilitate and accomplish cooperative efforts between resource management agencies and private landowners. The development of a candidate conservation agreements (with assurances) with interested parties would initiate conservation for the Texas fawnsfoot.
- The Service will continue working with resource management agencies and the Texas Department of Transportation (TxDOT) on developing best management practices for proposed adjacent/instream impacts specific to Texas water systems.
- The Service will continue working with resource management agencies and academia on developing a drought contingency plan that will facilitate the management and monitoring of mussel populations that harbor species of concern (i.e. the Texas fawnsfoot) during times of drought.
- The Service will continue working with resource management agencies, TxDOT, and academia on the development of standard mussel survey, relocation, and monitoring protocols, which would establish a commonality among the wide variety of methods currently being used in Texas and would establish a baseline of what kind of data needs to be collected while conducting surveys.
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References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2014. USFWS. 2019. Species status assessment report for the Central Texas Mussels, Version 1.5. December 2019. Albuquerque, NM.

89 FR. No. 108. Pages 48034-48130. Endangered and Threatened Wildlife and Plants

Endangered Species Status With Critical Habitat for Guadalupe Fatmucket, Texas Fatmucket, Guadalupe Orb, Texas Pimpleback, Balcones Spike, and False Spike, and Threatened Species Status With Section 4(d) Rule and Critical Habitat for Texas Fawnsfoot. Final Rule.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2019

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2020

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2021

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2022

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2023

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/30/2024

SPECIES ACCOUNT: *Villosa choctawensis* (Choctaw bean)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/10/2012; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A small, subelliptical, brown, faintly rayed freshwater mussel. The Choctaw bean is a small mussel with a moderately thick shell that obtains a maximum length of 49 mm. The shell is somewhat inflated, ovate in outline, with rounded anterior and posterior margins. Sexual dimorphism is present, in that females may be somewhat more broadly rounded posteriorly. The posterior ridge is low and rounded. The umbo is broad and full, extending little, if any, above hinge line and positioned well anterior of center. The periostracum is shiny and smooth. External shell color is chestnut to dark brown or black, with variable fine, green rays, which may be obscure in older specimens. Internally, two well-developed pseudocardinal teeth occur in left valve and one well-developed and two rudimentary pseudocardinal teeth are present in the right valve. The lateral teeth are short and almost straight. The interdentum is moderately wide and the umbo cavity is moderately deep. Shell nacre is white to bluish and sometimes iridescent, but may be blotched and brown (Garner et al., in review). See also Athearn (1964) and Deyrup and Franz (1994). (NatureServe, 2015)

Taxonomy

The Choctaw Bean was reassigned to the genus Obovaria (from Villosa) based on marsupial color, gravid female morphology, and mitochondrial DNA (Williams et al. 2011, Williams et al. 2014). The genus was formerly corrected for the species listed under protections of the Act (50 CFR 17.11) in the Federal Register to be consistent with this updated taxonomy (i.e., changed to Obovaria choctawensis) on February 17, 2022 (87 FR 8960). The present nomenclature is consistent with Williams et al. (2017) and Graf and Cummings (2021) (USFWS, 2022).

Historical Range

The Choctaw bean was originally thought to be endemic to the Escambia, Yellow, and Choctawhatchee River drainages in Alabama and Florida (Williams and Butler, 1994; Johnson, 1967). Due to recent status surveys the historical range of the Choctaw bean has been expanded (Williams et al., 2000; Blalock-Herod et al., 2005). (NatureServe, 2015)

Current Range

The species is restricted to Gulf Coast drainages from the Choctawhatchee River west to the Escambia River in southeastern Alabama and western Florida (Williams et al., 2008). (NatureServe, 2015)

Critical Habitat Designated

Yes; 10/10/2012.

Legal Description

On October 10, 2012, the U.S. Fish and Wildlife Service designated critical habitat for the Choctaw bean (Villosa choctawensis) under the Endangered Species Act of 1973, as amended (Act) (77 FR 61663 - 61719).

Critical Habitat Designation

The nuits designated as critical habitat for the choctaw bean are GCM1: Lower Escambia River, GCM3: Patsaliga Creek, GCM4: Upper Escambia River, GCM5: Yellow River, GCM6: Choctawhatchee River and Lower Pea River, and GCM7: Upper Pea River; totaling 1,397 miles in stream length.

Unit GCM1: Lower Escambia River Drainage, Florida and Alabama. Unit GCM1 encompasses 558 km (347 mi) of the lower Escambia River mainstem and 12 tributary streams in Escambia and Santa Rosa Counties, FL, and Escambia, Covington, Conecuh, and Butler Counties, AL. The unit consists of the main channel of the EscambiaConecuh River from the confluence of Spanish Mill Creek, Escambia and Santa Rosa counties, FL, upstream 204 km (127 mi) to the Point A Lake dam, Covington County, AL; Murder Creek from its confluence with the Conecuh River, Escambia County, AL, upstream 62 km (38 mi) to the confluence of Cane Creek, Conecuh County, AL; Burnt Corn Creek from its confluence with Murder Creek, Escambia County, AL, upstream 59 km (37 mi) to County Road 20, Conecuh County, AL; Jordan Creek from its confluence with Murder Creek, upstream 5.5 km (3.5 mi) to Interstate 65, Conecuh County, AL; Mill Creek from its confluence with Murder Creek upstream 2.5 km (1.5 mi) to the confluence of Sandy Creek, Conecuh County, AL; Sandy Creek from its confluence with Mill Creek upstream 5.5 km (3.5 mi) to County Road 29, Conecuh County, AL; Sepulga River from its confluence with the Conecuh River upstream 69 km (43 mi) to the confluence of Persimmon Creek, Conecuh County, AL; Bottle Creek from its confluence with the Sepulga River upstream 5.5 km (3.5 mi) to County Road 42, Conecuh County, AL; Persimmon Creek from its confluence with the Sepulga River, Conecuh County, upstream 36 km (22 mi) to the confluence of Mashy Creek, Butler County, AL; Panther Creek from its confluence with Persimmon Creek upstream 11 km (7 mi) to State Route 106, Butler County, AL; Pigeon Creek from its confluence with the Sepulga River, Conecuh and Covington Counties, upstream 89 km (55 mi) to the confluence of Three Run Creek, Butler County, AL; and Three Run Creek from its confluence with Pigeon Creek upstream 9 km (5.5 mi) to the confluence of Spring Creek, Butler County, AL. Unit GCM1 is within the geographical area occupied at the time of listing (2012) for the round ebonyshell, southern kidneyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Escambia River system is within the species' historical range, and we consider it essential to the southern kidneyshell's conservation due to the need to re-establish the species within other portions of its historical range in order to reduce threats from stochastic events. The unit currently supports populations of round ebonyshell, Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, cooccur with these five species. A diverse fish fauna, including potential fish host(s) for the fuzzy pigtoe, are known from the Escambia River drainage, indicating the potential presence of PCE 5. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to two upstream impoundments. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM3: Patsaliga Creek Drainage, Alabama. Unit GCM3 encompasses 149 km (92 mi) of Patsaliga Creek and two tributary streams in Covington, Crenshaw, and Pike Counties, AL, within the Escambia River basin. The unit consists of the Patsaliga Creek mainstem from its confluence with Point A Lake at County Road 59, Covington County, AL, upstream 108 km (67 mi) to Crenshaw County Road 66-Pike County Road 1 (the creek is the county boundary), AL; Little Patsaliga Creek from its confluence with Patsaliga Creek upstream 28 km (17 mi) to Mary Daniel Road, Crenshaw County, AL; and Olustee Creek from its confluence with Patsaliga Creek upstream 12 km (8 mi) to County Road 5, Pike County, AL. Unit GCM3 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Patsaliga Creek system is within the species' historic range. We consider it essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the Patsaliga Creek drainage, indicating the potential presence of PCE 5. Prior to construction of the Point A Lake and Gantt Lake dams in 1923, Patsaliga Creek drained directly to the Conecuh River main channel. It now empties into Point A Lake and is effectively isolated from the main channel by the dams. The dams are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM4: Upper Escambia River Drainage, Alabama. Unit GCM4 encompasses 137 km (85 mi) of the Conecuh River mainstem and two tributary streams in Covington, Crenshaw, Pike, and Bullock Counties, AL, within the Escambia River drainage. The unit consists of the Conecuh River from its confluence with Gantt Lake reservoir at the Covington-Crenshaw County line upstream 126 km (78 mi) to County Road 8, Bullock County, AL; Beeman Creek from its confluence with the Conecuh River upstream 6.5 km (4 mi) to the confluence of Mill Creek, Pike County, AL; and Mill Creek from its confluence with Beeman Creek, upstream 4.5 km (3 mi) to County Road 13, Pike County, AL. Unit GCM4 is is within the geographical area occupied at the time of listing (2012) Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Conecuh River is within the species' historic range, and we consider it to be essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species requiring similar PCEs co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the upper Escambia River drainage, indicating the potential presence of PCE 5. The Point A Lake and Gantt Lake dams on the Conecuh River mainstem are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM4: Upper Escambia River Drainage, Alabama. Unit GCM4 encompasses 137 km (85 mi) of the Conecuh River mainstem and two tributary streams in Covington, Crenshaw, Pike, and Bullock Counties, AL, within the Escambia River drainage. The unit consists of the Conecuh River from its confluence with Gantt Lake reservoir at the Covington-Crenshaw County line upstream

126 km (78 mi) to County Road 8, Bullock County, AL; Beeman Creek from its confluence with the Conecuh River upstream 6.5 km (4 mi) to the confluence of Mill Creek, Pike County, AL; and Mill Creek from its confluence with Beeman Creek, upstream 4.5 km (3 mi) to County Road 13, Pike County, AL. Unit GCM4 is is within the geographical area occupied at the time of listing (2012) Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell is not currently known to occur in the unit; however, this portion of the Conecuh River is within the species' historic range, and we consider it to be essential to the conservation of the southern kidneyshell due to the need to reestablish the species within other portions of its historic range in order to reduce threats from stochastic events. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species requiring similar PCEs co-occur with these four species. A diverse fish fauna, including a potential fish host for the fuzzy pigtoe, are known from the upper Escambia River drainage, indicating the potential presence of PCE 5. The Point A Lake and Gantt Lake dams on the Conecuh River mainstem are barriers to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological features includes the absence of fish hosts.

Unit GCM5: Yellow River Drainage, Florida and Alabama. Unit GCM5 encompasses 247 km (153 mi) of the Yellow River mainstem, the Shoal River mainstem, and three tributary streams in Santa Rosa, Okaloosa, and Walton Counties, FL, and Covington County, AL. The unit consists of the Yellow River from the confluence of Weaver River (a tributary located 0.9 km (0.6 mi), downstream of State Route 87), Santa Rosa County, FL, upstream 157 km (97 mi) to County Road 42, Covington County, AL; the Shoal River from its confluence with the Yellow River, Okaloosa County, FL, upstream 51 km (32 mi) to the confluence of Mossy Head Branch, Walton County, FL; Pond Creek from its confluence with Shoal River, Okaloosa County, FL, upstream 24 km (15 mi) to the confluence of Fleming Creek, Walton County, FL; and Five Runs Creek from its confluence with the Yellow River upstream 15 km (9.5 mi) to County Road 31, Covington County, AL. Unit GCM5 is within the geographical area occupied at the time of listing (2012) for the Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe. The southern kidneyshell was known from the Yellow River drainage; however, its occurrence in the basin is based on the collection of one specimen in 1919 from Hollis Creek in Alabama. We believe this single, historical record is not sufficient to consider this unit as essential to the conservation of the southern kidneyshell. Therefore, we are not designating Unit GCM5 as critical habitat for the southern kidneyshell at this time. The unit does currently support populations of Choctaw bean, narrow pigtoe, southern sandshell, and fuzzy pigtoe, indicating the presence of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these four species. A diverse fish fauna are known from the Yellow River drainage, indicating the potential presence of PCE 5.

Unit GCM6: Choctawhatchee River and Lower Pea River Drainages, Florida and Alabama. Unit GCM6 encompasses 897 km (557 mi) of the Choctawhatchee River mainstem, the lower Pea River mainstem, and 29 tributary streams in Walton, Washington, Bay, Holmes, and Jackson Counties, FL, and Geneva, Coffee, Dale, Houston, Henry, Pike, and Barbour Counties, AL. The unit consists of the Choctawhatchee River from the confluence of Pine Log Creek, Walton County, FL, upstream 200 km (125 mi) to the point the river splits into the West Fork Choctawhatchee and East Fork Choctawhatchee rivers, Barbour County, AL; Pine Log Creek from its confluence with the Choctawhatchee River, Walton County, upstream 19 km (12 mi) to the confluence of Ditch

Branch, Washington and Bay Counties, FL; an unnamed channel forming Cowford Island from its downstream confluence with the Choctawhatchee River upstream 3 km (2 mi) to its upstream confluence with the river, Washington County, FL; Crews Lake from its western terminus 1.5 km (1 mi) to its eastern terminus, Washington County, FL (Crews Lake is a relic channel southwest of Cowford Island, and is disconnected from the Cowford Island channel, except during high flows); Holmes Creek from its confluence with the Choctawhatchee River, Washington County, FL, upstream 98 km (61 mi) to County Road 4, Geneva County, AL; Alligator Creek from its confluence with Holmes Creek upstream 6.5 km (4 mi) to County Road 166, Washington County, FL; Bruce Creek from its confluence with the Choctawhatchee River upstream 25 km (16 mi) to the confluence of an unnamed tributary, Walton County, FL; Sandy Creek from its confluence with the Choctawhatchee River, Walton County, FL, upstream 30 km (18 mi) to the confluence of West Sandy Creek, Holmes and Walton County, FL; Blue Creek from its confluence with Sandy Creek, upstream 7 km (4.5 mi) to the confluence of Goose Branch, Holmes County, FL; West Sandy Creek from its confluence with Sandy Creek, upstream 5.5 km (3.5 mi) to the confluence of an unnamed tributary, Walton County, FL; Wrights Creek from its confluence with the Choctawhatchee River, Holmes County, FL, upstream 43 km (27 mi) to County Road 4, Geneva County, AL; Tenmile Creek from its confluence with Wrights Creek upstream 6 km (3.5 mi) to the confluence of Rice Machine Branch, Holmes County, FL; West Pittman Creek from its confluence with the Choctawhatchee River upstream 6.5 km (4 mi) to Fowler Branch, Holmes County, FL; East Pittman Creek from its confluence with the Choctawhatchee River upstream 4.5 km (3 mi) to County Road 179, Holmes County, FL; Parrot Creek from its confluence with the Choctawhatchee River upstream 6 km (4 mi) to Tommy Lane, Holmes County, FL; the Pea River from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 91 km (57 mi) to the Elba Dam, Coffee County, AL; Limestone Creek from its confluence with the Pea River upstream 8.5 km (5 mi) to Woods Road, Walton County, FL; Flat Creek from the Pea River upstream 17 km (10 mi) to the confluence of Panther Creek, Geneva County, AL; Eightmile Creek from its confluence with Flat Creek, Geneva County, AL, upstream 15 km (9 mi) to the confluence of Dry Branch (first tributary upstream of County Road 181), Walton County, FL; Corner Creek from its confluence with Eightmile Creek upstream 5 km (3 mi) to State Route 54, Geneva County, AL; Natural Bridge Creek from its confluence with Eightmile Creek Geneva County, AL, upstream, 4 km (2.5 mi) to the Covington-Geneva County line, AL; Double Bridges Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 46 km (29 mi) to the confluence of Blanket Creek, Coffee County, AL; Claybank Creek from its confluence with the Choctawhatchee River, Geneva County, AL, upstream 22 km (14 mi) to the Fort Rucker military reservation southern boundary, Dale County, AL; Claybank Creek from the Fort Rucker military reservation northern boundary, upstream 6 km (4 mi) to County Road 36, Dale County, AL; Steep Head Creek from the Fort Rucker military reservation western boundary, upstream 4 km (2.5 mi) to County Road 156, Coffee County, AL; Hurricane Creek from its confluence with the Choctawhatchee River upstream 14 km (8.5 mi) to State Route 52, Geneva County, AL; Little Choctawhatchee River from its confluence with the Choctawhatchee River, Dale and Houston Counties upstream 20 km (13 mi) to the confluence of Newton Creek, Houston County, AL; Panther Creek from its confluence with the Little Choctawhatchee River, upstream 4.5 km (2.5 mi) to the confluence of Gilley Mill Branch, Houston County, AL; Bear Creek from its confluence with the Little Choctawhatchee River, upstream 5.5 km (3.5 mi) to County Road 40 (Fortner Street), Houston County, AL; West Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 54 km (33 mi) to the fork of Paul’s Creek and Lindsey Creek, Barbour County, AL; Judy Creek from its confluence with West Fork Choctawhatchee River upstream 17 km (11 mi) to County Road 13, Dale County, AL; Sikes Creek from its confluence with West Fork

Choctawhatchee River, Dale County, AL, upstream 8.5 km (5.5 mi) to State Route 10, Barbour County, AL; Paul's Creek from its confluence with West Fork Choctawhatchee River upstream 7 km (4.5 mi) to one mile upstream of County Road 20, Barbour County, AL; Lindsey Creek from its confluence with West Fork Choctawhatchee River upstream 14 km (8.5 mi) to the confluence of an unnamed tributary, Barbour County, AL; an unnamed tributary to Lindsey Creek from its confluence with Lindsey Creek upstream 2.5 km (1.5 mi) to 1.0 mile upstream of County Road 53, Barbour County, AL; and East Fork Choctawhatchee River from its confluence with the Choctawhatchee River, Dale County, AL, upstream 71 km (44 mi) to County Road 71, Barbour County, AL. Unit GCM6 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the Choctawhatchee River, including a potential fish host for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. Not included in this unit are two oxbow lakes now disconnected from the Choctawhatchee River main channel in Washington County, Florida. Horseshoe Lake has a record of southern kidneyshell from 1932, and Crawford Lake has records of Choctaw bean and tapered pigtoe from 1934. It is possible these oxbow lakes had some connection to the main channel when the collections were made over 75 years ago. The three species are not currently known to occur in Horseshoe or Crawford lakes, and we do not consider them essential to the conservation of the southern kidneyshell, Choctaw bean, or tapered pigtoe. Threats to the five species and their habitat that may require special management of the physical or biological features include the potential of significant changes in the existing flow regime and water quality due to the Elba Dam on the Pea River mainstem. As discussed in Summary of Factors Affecting the Species, mollusk declines downstream of dams are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and altered water temperatures, and changes in resident fish assemblages. These alterations can cause mussel declines for many miles downstream of the dam.

Unit GCM7: Upper Pea River Drainage, Alabama. Unit GCM7 encompasses 234 km (145 mi) of the upper Pea River mainstem and six tributary streams in Coffee, Dale, Pike, Barbour, and Bullock Counties, AL. This unit is within the Choctawhatchee River basin and includes the stream segments upstream of the Elba Dam. The unit consists of the Pea River from the Elba Dam, Coffee County, upstream 123 km (76 mi) to State Route 239, Bullock and Barbour Counties, AL; Whitewater Creek from its confluence with the Pea River, Coffee County upstream 45 km (28 mi) to the confluence of Walnut Creek, Pike County, AL; Walnut Creek from its confluence with Whitewater Creek upstream 14 km (9 mi) to County Road 26, Pike County, AL; Big Creek (Coffee County) from its confluence with Whitewater Creek, Coffee County, upstream 30 km (18 mi) to the confluence of Smart Branch, Pike County, AL; Big Creek (Barbour County) from its confluence with the Pea River upstream 10 km (6 mi) to the confluence of Sand Creek, Barbour County, AL; Pea Creek from its confluence with the Pea River upstream 6 km (4 mi) to the confluence of Hurricane Creek, Barbour County, AL; and Big Sandy Creek from its confluence with the Pea River upstream 6.5 km (4 mi) to County Road 14, Bullock County, AL. Unit GCM7 is within the geographical area occupied at the time of listing (2012) for the southern kidneyshell, Choctaw bean, tapered pigtoe, southern sandshell, and fuzzy pigtoe. The unit currently supports populations of the five species, indicating the elements of essential physical or biological features, and contains PCEs 1, 2, 3, and 4. In addition, other mussel species, requiring similar PCEs, co-occur with these five species. A diverse fish fauna is known from the upper Pea River, including potential fish host(s) for the fuzzy pigtoe and tapered pigtoe, indicating the potential presence of PCE 5. The Elba Dam on the Pea River mainstem is a barrier to upstream fish movement, particularly to anadromous fishes. Therefore, a potential threat that may require special management of the physical or biological feature includes the absence of potential host fishes.

Primary Constituent Elements/Physical or Biological Features

Within the critical habitat units, the primary constituent elements of the physical or biological features essential to the conservation of the Choctaw bean consist of five components:

(i) Geomorphically stable stream and river channels and banks (channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation).

(ii) Stable substrates of sand or mixtures of sand with clay or gravel with low to moderate amounts of fine sediment and attached filamentous algae.

(iii) A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats where the species are found, and to maintain connectivity of rivers with the floodplain, allowing the exchange of nutrients and sediment for habitat maintenance, food availability, and spawning habitat for native fishes.

(iv) Water quality, including temperature (not greater than 32 °C), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 milligrams per liter), hardness, turbidity, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages.

(v) The presence of fish hosts. Diverse assemblages of native fish species will serve as a potential indication of host fish presence until appropriate host fishes can be identified. For the fuzzy pigtoe and tapered pigtoe, the presence of blacktail shiner (Cyprinella venusta) will serve as a potential indication of fish host presence.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, dams, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 9, 2012, with the exception of the impoundments created by Point A and Gantt Lake dams (impounded water, not the actual dam structures).

Many of the threats to this mussel and their habitat are pervasive and common in all of the units that are designated as critical habitat. These include the potential of significant changes in stream bed material composition and quality by activities such as construction projects, livestock grazing, timber harvesting, and other watershed and floodplain disturbances that release sediments or nutrients into the water; the potential of significant alteration of water chemistry or water quality; the potential of anthropogenic activities such as channelization, impoundment, and channel excavation that could cause aggradation or degradation of the channel bed elevation or significant bank erosion; and the potential of significant changes in the existing flow regime due to such activities as impoundment, water diversion, or water withdrawal. Because the areas designated as critical habitat below are facing these threats, they require special management consideration and protection.

Life History

Feeding Narrative

Adult: Presumably fine particulate organic matter, primarily detritus, and/or zooplankton, and/or phytoplankton (Fuller, 1974). Larvae (glochidia) of freshwater mussels generally are parasitic on fish and there may be a specificity among some species. Adults are detritivores, while larvae are parasitic (NatureServe, 2015). Adults are filter feeders and generally orient themselves on or near the substrate surface to take in food and oxygen from the water column. Juveniles typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994, pp. 200–221; Gatenby et al. 1996, p. 604) (USFWS, 2012).

Reproduction Narrative

Adult: Probably tachytictic (short-term brooder) as are other, more northerly members of the genus.; Found in sometimes difficult-to-collect larger streams, which probably accounts for its relatively recent discovery. It has one of the most restricted ranges of any member of the genus (NatureServe, 2015). Females gravid from late summer or autumn to the following summer. Its fish host is currently unknown (Williams et al. 2008, p. 758) (USFWS, 2012). Field examination of 43 females (9 gravid) indicates the Choctaw Bean is a long-term brooder and gravid from late summer or autumn through the spring (FWC unpubl. data collected 2013– 2021). Fish hosts have not been identified; however, the Choctaw Bean may be a host specialist like other species of Obovaria (Williams et al. 2014). In the adjacent Mobile River basin, O. unicolor and O. arkansasensis use darters and shiners as hosts (USFWS, 2022)

Geographic or Habitat Restraints or Barriers

Adult: Lack of lotic connections, water depth > 10 m, impoundments (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (USFWS, 2012; see threats)

Environmental Specificity

Adult: Very narrow to moderate (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low to moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: The Choctaw bean is known from large creeks and rivers with moderate current over sand to silty-sand substrates (Deyrup and Franz, 1994; Williams and Butler, 1994). This species is highly to moderately vulnerable to threats and the environmental specificity is very narrow to moderate. Separation barriers between standing water bodies and within flowing water systems include lack of lotic connections, natural barriers such as upland habitat, absence of appropriate species specific fish hosts, water depth greater than 10 meters (Cvancara, 1972; Moyle and

Bacon, 1969) or anthropogenic barriers to water flow such as dams or other impoundments and high waterfalls (NatureServe, 2015). Primary constituent elements include: geomorphically stable stream and river channels and banks; stable substrates; a hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain benthic habitats; water quality, including temperature (not greater than 32 oC), pH (between 6.0 to 8.5), oxygen content (not less than 5.0 mg/L) (USFWS, 2012)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dependency on Other Individuals or Species for Dispersal

Adult: Host fish (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate although some passive movement downstream may occur during high flows. Dispersal occurs while the glochidia are encysted on their host (probably a fish). This species is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 30 - 50% (NatureServe, 2015)

Species Trends:

Declining (NatureServe, 2015)

Number of Populations:

2 (USFWS, 2021)

Population Size:

between 8,100 and 9,475 plants (USFWS, 2021)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

At the time of listing, this species was only known from 17 distinct occurrences along a single 4 mile reach of the Sipsey Fork within the Bankhead National Forest, in Winston County, Alabama. Two additional occurrences were documented since the time of listing, however the species continues to only be found in one drainage. Five of the original occurrences were revisited in 2014, 2015 and 2016 without relocating plants, however, the range of the species remains the same. Due to the close proximity of the existing sites to each other, all of the sites have been regrouped into two populations according to Alabama Natural Heritage Networks definition of what constitutes an individual population (Al Schotz, Alabama Natural Heritage Program, February 12, 2021, pers. comm.). Most of this reach of Sipsey Fork where the populations occur is protected under Forest Service management, but some of the stream bank is in private ownership not subject to Forest Service management guidelines or take provisions of the ESA. Most of the occurrences are located in Bankhead National Forest; however, at least four sites and a portion of a fifth site, are located on private inholdings. (USFWS, 2021) Data gathered through the ALNHP study, determined the estimate of T. burksiorum to be between 8,100 and 9,475 plants distributed among 14 remaining occurrences Godwin and Schotz 2017). No discernable trends were apparent in number of plants among the four monitoring plots sampled during the project from 2013-2017. (USFWS, 2021)

Threats and Stressors

Stressor: Habitat loss and degradation (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Premier threat is habitat loss or degradation. The stream and river habitats are vulnerable to habitat modification, sedimentation, and water quality degradation from a number of activities. Highway and reservoir construction, improper logging practices, agricultural runoff, housing developments, pipeline crossings, and livestock grazing often result in physical disturbance of stream substrates or the riparian zone, and/or changes in water quality, temperature, or flow. Sedimentation can cause direct mortality of mussels by deposition and suffocation (Ellis, 1936; Brim Box and Mossa, 1999) and can eliminate or reduce the recruitment of juvenile mussels (Negus, 1966; Brim Box and Mossa, 1999). Suspended sediment can also interfere with feeding activity of mussels (Dennis, 1984). Many of the confirmed extant populations of this species are in the vicinity of highway and unpaved road crossings due to ease of access for surveyors. Highway and bridge construction and widening could affect populations of these species unless appropriate precautions are implemented during construction to reduce erosion and sedimentation, and maintain water quality standards. The construction of reservoirs and the associated habitat changes (e.g., changes of sediments, flow, water temperature, dissolved oxygen) can directly impact mussel populations (Neves et al., 1997). Nutrients, usually phosphorus and nitrogen, may emanate from agricultural fields, residential lawns, livestock feedlots, poultry houses, and leaking septic tanks in levels that result in eutrophication and reduced oxygen levels in small streams (NatureServe, 2015).

Stressor: Stochastic events (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The Gulf coastal region is prone to extreme hydrologic events. During high flows, flood scour can dislodge mussels where they may be injured, buried, or swept into unsuitable habitats, or mussels may be stranded and perish when flood waters recede (Vannote and Minshall 1982, p. 4105; Tucker 1996, p. 435; Hastie et al. 2001, pp. 107–115; Peterson et al. 2011, unpaginated).

During drought, stream channels may become disconnected pools where mussels are exposed to higher water temperatures, lower dissolved oxygen levels, and predators, or channels may become dewatered entirely. Specific effects of climate change to mussels, their habitat, and their fish hosts could include changes in stream temperature regimes, the timing and levels of precipitation causing more frequent and severe floods and droughts, and alien species introductions. The linear nature of their habitat, reduced range, and small population sizes makes this species vulnerable to contaminant spills (USFWS, 2012).

Stressor: Reduced genetic diversity (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Population fragmentation and isolation prohibits the natural interchange of genetic material among populations. Low numbers of individuals within the isolated populations have greater susceptibility to deleterious genetic effects, including inbreeding depression and loss of genetic variation (Lynch 1996, pp. 493– 494). Small, isolated populations, therefore, are more susceptible to environmental pressures, including habitat degradation and stochastic events, and thus are the most susceptible to extinction (Primack 2008, pp. 151–153) (USFWS, 2012).

Stressor: Nonindigenous species (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The Asian clam (Corbicula fluminea) has been introduced to the drainages and may be adversely affecting these eight mussels through direct competition for space and resources. The flathead catfish (Pylodictis olivaris) has been introduced to the drainages and may be adversely impacting native fish populations (USFWS, 2012).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Recovery Priority Number: 5

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS • Initiate at least semi-annual long-term monitoring on sites located on the Sipsey Fork. • Attempt to locate additional populations in nearby drainages. • Work to obtain protection for sites on privately-owned lands. • Research life history parameters and propagation techniques. • Continue to work cooperatively with the Bankhead National Forest to evaluate potential impacts to the plant from recreational use and implement corrective measures. • Enter into an MOU to work toward the recovery of this plant through the development of

conservation measures. • Periodic monitoring is encouraged to assess population trends, specifically in relation to climate change. Because of the species' narrow ecological niche, ongoing research is recommended to assess the impacts of climate change on the plants themselves and their habitat. (USFWS, 2021)

- RECOMMENDED FUTURE ACTIVITIES These seven species do not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities, which are included below. Recovery Activities a. Encourage the protection and establishment of wide riparian buffer zones along all streams containing or draining into the historical ranges of these species. Buffers of at least 300 feet in width and consisting of native forest are considered the most protective and effective. A greater width may be necessary to effectively buffer storm water runoff from urban and suburban lands, cultivated fields, and timber harvest operations. b. Restore and increase in-stream habitat and stream connectivity through conservation actions, including but not limited to removing artificial fish migration barriers, bank stabilization, riparian buffer maintenance or augmentation, improving water quality downstream of impoundments, and adherence to BMPs. c. Work with state and federal agencies and private organizations to promote land and water stewardship awareness (e.g., Soil and Water Conservation Districts, Natural Resource Conservation Service (NRCS), State Forestry Commissions, private industry groups, environmental groups, etc.). d. Develop programs and outreach materials to increase public awareness of these species and explain the benefits of protecting stream ecosystems. Monitoring and Research Activities a. Conduct status survey for Round Ebonyshell in the Conecuh River and document habitat conditions. b. Conduct surveys in under sampled portions of their ranges to examine the species’ status and habitat conditions. c. Conduct quantitative assessments of mussel assemblages to examine relative abundance, catch per unit effort, and population demographics. d. Conduct long-term monitoring studies to obtain demographic data, including population estimates, population growth rates, recruitment levels, and age-specific survival. e. Use eDNA as a detection tool to provide up-to-date distributional information, especially for rare or cryptic species like Southern Kidneyshell. Use assays to confirm presence in historical reaches and detect previously unknown populations. f. Conduct long-term monitoring studies of stream thermal regimes, especially during summer low flow conditions. g. Prepare a comprehensive threats assessment that identifies and maps existing and potential threats within the watersheds and identifies activities or practices that may affect the seven mussels or their habitats. Use the assessment to develop SSAs and recovery plans for the species. h. Model future precipitation, temperature, and flow scenarios in the basins to examine the impacts of climate change and consumptive uses. Use the assessment to develop SSAs and recovery plans for the species. i. Model future sea level and flow scenarios to analyze the effects of saltwater encroachment in the lower mainstems during high tide and storm surge events. Use the assessment to develop SSAs and recovery plans for the species. j. Research important life-history traits, such as host fish use, growth, longevity, age at maturity, and fecundity, and incorporate the results into management and protection actions. All partners should be aware of research efforts and results to facilitate the immediate application of results. k. Determine temperature and contaminant sensitivity for each life-stage, and develop recommendations for EPA and state water quality criteria to protect and enhance habitat. l. Conduct genetic analysis to determine adaptive capacity, evaluate species boundaries, and establish genetic management plans. m. Study the life history and identify the host fish of the Southern Sandshell, Choctaw Bean, and Round Ebonyshell (USFWS, 2022).

References

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/speciesProfile/. Accessed April 2016. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat. Final rule. 77 FR 61663 - 61719 (October 10, 2012).

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS 2012. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for the Alabama Pearlshell, Round Ebonyshell, Southern Kidneyshell, and Choctaw Bean, and Threatened Species Status for the Tapered Pigtoe, Narrow Pigtoe, Southern Sandshell, and Fuzzy Pigtoe, and Designation of Critical Habitat

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719. USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2021. Alabama streak-sorus fern Thelypteris pilosa var. alabamensis (= T. burksiorum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 12 pp.

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Final Rule. 77 Federal Register 196. October 10, 2012. Pages 61663 - 61719.

USFWS. 2021. Alabama streak-sorus fern Thelypteris pilosa var. alabamensis (= T. burksiorum) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 12 pp.

USFWS. 2022. Round Ebonyshell, Reginaia rotulata Southern Kidneyshell, Ptychobranchus jonesi Choctaw Bean, Obovaria choctawensis Tapered Pigtoe, Fusconaia burkei Narrow Pigtoe, Fusconaia escambia Southern Sandshell, Hamiota australis Fuzzy Pigtoe, Pleurobema strodeanum. Status

Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Panama City, Florida. 54 pp.

SPECIES ACCOUNT: *Villosa fabalis* (Rayed bean)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The rayed bean is a small mussel, usually less than 1.5 inches (in) 3.8 centimeters (cm) in length (Cummings and Mayer 1992; Parmalee and Bogan 1998; West et al. 2000). The shell outline is elongate or ovate in males and elliptical in females, and moderately inflated in both sexes, but more so in females (Parmalee and Bogan 1998). The valves are thick and solid. The anterior end is rounded in females and bluntly pointed in males (Cummings and Mayer 1992). Females are generally smaller than males (Parmalee and Bogan 1998). Dorsally, the shell margin is straight, while the ventral margin is straight to slightly curved (Cummings and Mayer 1992). The beaks are slightly elevated above the hingeline (West et al. 2000), with sculpture consisting of double loops with some nodules (Parmalee and Bogan 1998). No posterior ridge is evident. Surface texture is smooth and sub-shiny, and green, yellowish-green, or brown in color, with numerous, wavy, dark-green rays of various widths (sometimes obscure in older, blackened specimens) (Cummings and Mayer 1992; West et al. 2000). Internally, the left valve has two pseudocardinal teeth (tooth-like structures along the hingeline of the internal portion of the shell) that are triangular, relatively heavy, and large, and two short, heavy lateral teeth (Cummings and Mayer 1992). The right valve has a low, triangular pseudocardinal tooth, with possibly smaller secondary teeth anteriorly and posteriorly, and a short, heavy, and somewhat elevated lateral tooth (Parmalee and Bogan 1998). The color of the nacre (mother-of-pearl) is silvery white or bluish and iridescent posteriorly. Key characters useful for distinguishing the rayed bean from other mussels are its small size, thick valves, unusually heavy teeth for a small mussel, and color pattern (Cummings and Mayer 1992).

Taxonomy

The rayed bean is a member of the freshwater mussel family Unionidae and was originally described as Unio fabalis by Lea in 1831 (pp. 86–87). The type locality (the location of the first identified specimen) is the Ohio River (Parmalee and Bogan 1998, p. 244), probably in the vicinity of Cincinnati, Ohio. Over the years, the rayed bean has been placed in the genera Unio, Margarita, Margaron, Eurynia, Micromya, and Lemiox. It was ultimately placed in the genus Villosa by Stein (1963, p. 19), where it remains today (Turgeon et al. 1998, p. 33). We recognize Unio capillus, U. lapillus, and U. donacopsis as synonyms of Villosa fabalis.

Historical Range

The rayed bean historically occurred in 115 streams, lakes, and some humanmade canals in 10 States: Illinois, Indiana, Kentucky, Michigan, New York, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia; and Ontario, Canada. The mussel occurred in parts of the upper (Lake Michigan drainage) and lower Great Lakes systems, and throughout most of the Ohio and Tennessee River systems. During historical times, the rayed bean was fairly widespread and locally common in many Ohio River system streams based on collections made over a several-decade period. The species was once fairly common in the Belle, South Branch Thames, Detroit, Scioto, Wabash, and Duck Rivers; several tributaries in the Scioto system (Olentangy River, and Big Darby and Alum Creeks); and Tippecanoe Lake, based on literature and museum records (Call 1900; Watters 1994, p. 105; West et al. 2000, p. 251; Badra 2002, pers. comm.). The rayed bean was last reported from some streams several decades ago (North Branch Clinton, Auglaize, Ohio, West Fork, Beaver, Shenango, Mahoning, Mohican, Scioto, Green, Barren, Salamonie, White, Big Blue, Tennessee, Holston, South Fork Holston, Nolichucky, Clinch, North Fork Clinch, and Powell Rivers; Wolf, Conewango, Oil, Crooked, Pymatuning, Mill, Alum, Whetstone, Deer, Lick, and Richland Creeks; and Buckeye, Tippecanoe, Winona, and Pike Lakes). The rayed bean population in Lake Erie was once considerable (Ohio State University Museum of Biological Diversity (OSUM) collections), but has been eliminated by the zebra mussel.

Current Range

Extant populations of the rayed bean are known from 31 streams and 1 lake in seven States and 1 Canadian province: Indiana (St. Joseph River (Fish Creek), Tippecanoe River (Lake Maxinkuckee, Sugar Creek)), Michigan (Black River (Mill Creek), Pine River, Belle River, Clinton River), New York (Allegheny River (Olean Creek, Cassadaga Creek)), Ohio (Swan Creek, Fish Creek, Blanchard River, Tymochtee Creek, Walhonding River, Mill Creek, Big Darby Creek, Scioto Brush Creek; Great Miami River, Little Miami River (East Fork Little Miami River), Stillwater River), Pennsylvania (Allegheny River (French Creek (Le Boeuf Creek, Muddy Creek, Cussewago Creek))), Tennessee (Duck River), and West Virginia (Elk River); and Ontario, Canada (Sydenham River, Thames River).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Mussel biologists know relatively little about the specific life-history requirements of the rayed bean. Most mussels, including the rayed bean, have separate sexes. The age at sexual maturity, which is unknown for the rayed bean, is highly variable (0–9 years) among and within species (Haag and Staton 2003), and may be sex-dependent (Smith 1979). The rayed bean is thought to be a long-term brooder, with females brooding glochidia from May through October (Parmalee and Bogan 1998; Ecological Specialists, Inc. (ESI) 2000; Woolnough 2002). Tippecanoe darter (Etheostoma tippecanoe) and spotted darter (Etheostoma maculatum) are the only verified host fish for the rayed bean (White et al. 1996, Watters 2011). Other rayed bean hosts are thought to include the greenside darter (E. blennioides), rainbow darter (E. caeruleum), mottled sculpin (Cottus bairdi), and largemouth bass (Micropterus salmoides) (Woolnough 2002). Based on inference of closely related species, additional hosts may be suitable, including other darter and sculpin species (Jones 2002, pers. comm.).

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: The rayed bean is generally known from smaller, headwater creeks, but occurrence records exist from larger rivers (Cummings and Mayer 1992, p. 142; Parmalee and Bogan 1998, p. 244). They are usually found in or near shoal or riffle (short, shallow length of stream where the stream flows more rapidly) areas, and in the shallow, wave-washed areas of glacial lakes, including LakeErie (West et al. 2000, p. 253). In Lake Erie, the species is generally associated with islands in the western portion of the lake. Preferred substrates typically include gravel and sand. The rayed bean is oftentimes found among vegetation (water willow (Justicia americana) and water milfoil (Myriophyllum sp.)) in and adjacent to riffles and shoals (Watters 1988b, p. 15; West et al. 2000, p. 253). Specimens are typically buried among the roots of the vegetation (Parmalee and Bogan 1998, p. 245). Adults and juveniles appear to produce byssal threads (thin, protein-based fibers) (Woolnough 2002, pp. 99–100), apparently to attach themselves to substrate particles.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
73 percent decline

Number of Populations:
22 extant populations (USFWS, 2023). 37 occupied streams.

Population Size:
greater than 1,000,000 individuals

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Based on historical and current data, the rayed bean has declined significantly rangewide and is now known from only 31 streams and 1 lake (down from 115), a 73 percent decline. This species has also been eliminated from long reaches of former habitat in hundreds of miles of the Maumee, Ohio, Wabash, and Tennessee Rivers and from numerous stream reaches and their tributaries. In addition, this species is no longer known from the States of Illinois, Kentucky, and Virginia. The rayed bean was also extirpated in West Virginia until the 2006 reintroduction into the Elk River (Clayton 2007, pers. comm.; USFWS 2012). The rayed bean has experienced a significant reduction in range and most of its populations are disjunct, isolated, and, with few exceptions, appear to be declining (West et al. 2000). The extirpation of this species from over 80 streams and other water bodies within its historical range indicates that substantial population losses have occurred (USFWS 2012). Relatively few streams are thought to harbor sizable viable populations (Sydenham, Blanchard, and Allegheny Rivers, and French and Swan Creeks). Small population size and restricted stream reaches of current occurrence are real threats to the rayed bean due to the negative genetic aspects associated with small, geographically isolated populations. This can be especially true for a species, like the rayed bean, that was historically widespread and had population connectivity among mainstem rivers and multiple tributaries (USFWS 2012). The majority of the remaining populations of rayed bean are generally small and geographically isolated (Butler 2002). The patchy distributional pattern of populations in short river reaches makes those populations much more susceptible to

extirpation from single catastrophic events, such as toxic chemical spills (Watters and Dunn, 1993–94). Furthermore, this level of isolation makes natural repopulation of any extirpated population virtually impossible without human intervention. Various nonnative species of aquatic organisms are firmly established in the range of the rayed bean; however, the exotic species that poses the most significant threat to these species is the zebra mussel (Dreissena polymorpha) (Butler 2002). The rayed bean was listed as endangered in 2012. At the time of listing, the rayed bean was thought to be extant in 31 streams and 1 lake in 7 states and 1 Canadian province: Indiana (St. Joseph River (Fish Creek), Tippecanoe River (Lake Maxinkuckee, Sugar Creek)), Michigan (Black River (Mill Creek), Pine River, Belle River, Clinton River), New York (Allegheny River (Olean Creek, Cassadaga Creek)), Ohio (Swan Creek, Fish Creek, Blanchard River, Tymochtee Creek, Walhonding River, Mill Creek, Big Darby Creek, Scioto Brush Creek, Great Miami River (Stillwater River), Little Miami River (East Fork Little Miami River)), Pennsylvania (Allegheny River (French Creek (Le Boeuf Creek, Muddy Creek, Cussewago Creek))), Tennessee (Duck River), and West Virginia (Elk River); and Ontario, Canada (Sydenham River, Thames River). In 2015, one extant population was discovered in Michigan in the River Raisin and two extant populations were discovered in New York in Oil and Oswayo Creeks (TRC Environmental Corporation 2015; EcoLogic, LLC 2014b; EcoLogic, LLC 2015). The rayed bean is currently considered to be extant in 34 streams and 1 lake. Table 1 provides a population summary for all extant rayed bean locations. Populations are considered to be large if they have a sizable population that is generally distributed over a significant, and more or less contiguous length of stream, with ample evidence of recent recruitment. The U.S. Fish and Wildlife Service (Service) currently has no updated information since the time of listing for the following 15 streams and 1 lake: Black River (MI), Mill Creek (MI), Pine River (MI), Clinton River (MI), Olean Creek (NY), Le Bouef Creek (PA), Muddy Creek (PA), Walhonding River (OH), Mill Creek (OH), Big Darby Creek (OH), Scioto Brush Creek (OH), Great Miami River (OH), Stillwater River (OH), Little Miami River (OH), East Fork Little Miami River (OH), and Lake Maxinkuckee (IN). At the time of listing, the rayed bean population size in all of these 16 locations was considered to be either small or unknown and the population trend either declining or unknown (Table 1). Based on the absence of any updated information on these populations, the known status of these populations remains unchanged since the species was listed in 2012. For six streams, new information available since the publication of the final listing rule (2012) is limited to records of one to several live and/or fresh dead individuals. These six streams are the Belle River (MI), St. Joseph River (OH), Fish Creek (OH), Cussewago Creek (PA), Tippecanoe River (IN), and Sugar Creek (IN). At the time of listing, the rayed bean population size in these locations was considered to be either small or unknown and the population trend either declining or unknown (Table 1). Based on the lack of new population-level information, the status of these populations remains unchanged since the species was listed in 2012. Since the time of listing, new information has become available for 10 previously known populations and 3 recently discovered populations. The following is a summary of this new information for each of these 13 populations (USFWS, 2018). Currently the rayed bean occurs in seven states, as well as the Canadian province of Ontario (Figure 1). For the 2022 SSA, we described and analyzed the distribution of the rayed bean in terms of watersheds occupied, delineated by the U.S. Geological Survey (USGS) based on surface hydrological features. These hydrological areas are identified as hydrological units at various geographic scales (referred to as HUC). In the 2022 SSA, we used the HUC2 scale to delineate three representation units for the rayed bean: Great Lakes, Ohio, and Tennessee Basins. The species currently ranges across all three representation units. In the SSA, we used the HUC8 at the subbasin scale to define a population of the rayed bean and conduct our current condition analysis. Defining a population at the HUC8 scale resulted in 19 extant populations range wide. New data obtained since the completion of the SSA documents that the species currently has 22 extant HUC8 populations, which includes a total of 37 occupied streams(USFWS, 2023).

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: Impoundments result in the dramatic modification of riffle and shoal habitats and a resulting loss of mussel resources, especially in larger rivers. Neves et al. (1997, pp. 63–64) and Watters (2000, pp. 261–262) reviewed the specific effects of impoundments on freshwater mollusks. Dams interrupt a river's ecological processes by modifying flood pulses; controlling impounded water elevations; altering water flow, sediments, nutrients, and energy inputs and outputs; increasing depth; decreasing habitat heterogeneity; decreasing stability due to subsequent sedimentation; blocking host fish passage; and isolating mussel populations from fish hosts. Even small, low-head dams can have some of these effects on mussels. The reproductive process of riverine mussels is generally disrupted by impoundments, making the rayed bean and snuffbox unable to successfully reproduce and recruit under reservoir conditions. Population losses due to impoundments have likely contributed more to the decline and imperilment of the rayed bean and snuffbox than has any other single factor. Neither species occurs in reservoirs lacking riverine characteristics, although both persist in some reaches of large rivers with dams (Ohio River and Allegheny River), they are restricted to sections retaining riverine characteristics (generally tailwaters). Both species, however, historically occurred in the wavewashed shallows of several glacial lakes, an environment very different from that found in impoundments.

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Excessive sedimentation affects an estimated 28 percent of all U.S. streams (Judy et al. 1984, p. 38), including the majority of the streams with extant rayed bean and snuffbox populations. Sedimentation has been implicated in the decline of mussel populations nationwide and is a threat to rayed bean and snuffbox (Kunz 1898, p. 328; Ellis 1936, pp. 39–40; Marking and Bills 1979, p. 204; Vannote and Minshall 1982, p. 4105–4106; Dennis 1984, p. 212; Wolcott and Neves 1990, pp. 74–75; Brim Box 1999, p. 79; Fraley and Ahlstedt 2000, p. 194; Poole and Downing 2004, pp. 119–120). Specific biological impacts include reduced feeding and respiratory efficiency due to clogged gills, disrupted metabolic processes, reduced growth rates, limited burrowing activity, and physical smothering (Ellis 1936, pp. 39–40; Stansbery 1971, p. 6; Imlay 1972, p. 76; Marking and Bills 1979, p. 210; Vannote and Minshall 1982, p. 4105; Waters 1995, p. 7). Studies indicate that excessive sediment level impacts are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999, p. 101). Physical habitat effects include altered suspended and bed material loads, and bed sediment composition associated with increased sediment production and run-off; clogged interstitial habitats and reduced interstitial flow rates and dissolved oxygen levels; changed channels in form, position, and degree of stability; altered depth or width-depth ratio that affects light penetration and flow regime;

aggraded (filling) or degraded (scouring) channels; and changed channel positions that dewater mussel beds (Vannote and Minshall 1982, p. 4105; Gordon et al. 1992, pp. 296–297; Kanehl and Lyons 1992, pp. 26–27; Brim Box and Mossa 1999, p. 102). Interstitial spaces in the substrate provide essential habitat for juvenile mussels. When they are clogged, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999, p. 100), thus reducing juvenile habitat availability. The rayed bean burrows deep into interstitial substrates, making it particularly susceptible to degradation of this habitat. Sediment may act as a vector for delivering contaminants, such as nutrients and pesticides, to streams. Juveniles can readily ingest contaminants adsorbed to silt particles during normal feeding activities. These factors may explain, in part, why so many mussel populations, including those of the rayed bean and snuffbox, appear to be experiencing recruitment failures.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Chemical contaminants are ubiquitous throughout the environment and are considered a major threat in the decline of freshwater mussel species (Cope et al. 2008, p. 451; Richter et al. 1997, p. 1081; Strayer et al. 2004, p. 436; Wang et al. 2007, p. 2029). Chemicals enter the environment through both point and nonpoint discharges, including spills, industrial sources, municipal effluents, and agricultural runoff. These sources contribute organic compounds, heavy metals, pesticides, and a wide variety of newly emerging contaminants to the aquatic environment. As a result, water and sediment quality can be degraded to the extent that mussel populations are adversely impacted.

Stressor: Mining
Exposure:
Response:
Consequence:
Narrative: The low pH commonly associated with coal mine runoff can reduce glochidial encystment rates, thus impacting mussel recruitment (Huebner and Pynno¨nen 1992, p. 2350). Additionally, adverse impacts from heavy-metal-rich drainage from coal mining and associated sedimentation have been documented in portions of historical rayed bean and snuffbox habitat in the upper Ohio River system in western Pennsylvania (Ortmann 1909c, p. 97), West Virginia, and southeastern Ohio. Likewise, coal mining has impacted rayed bean habitat in the upper Tennessee River system, Virginia (Kitchel et al. 1981, p. 21), and snuffbox habitat in eastern Kentucky (lower Ohio and Mississippi River systems in southeastern Illinois and western Kentucky; upper Cumberland River system in southeastern Kentucky and northeastern Tennessee; and upper Tennessee River system in southwestern Virginia) (Ortmann 1909c, p. 103; Neel and Allen 1964, pp. 428–430; Kitchel et al. 1981, p. 21; Anderson et al. 1991, pp. 6–7; Gordon 1991, p. 2; Bogan and Davis 1992, p. 2; Layzer and Anderson 1992, pp. 91–94; Ahlstedt and Tuberville 1997, p. 75; Milam et al. 2000, p. 53; Warren and Haag 2005, p. 1394). Acid mine drainage was implicated in the mussel die-off in the Little South Fork Cumberland River, Kentucky (Anderson et al. 1991, pp. 6–7; Layzer and Anderson, 1992, p. 94; Ahlstedt and Saylor 1995–96, pp. 92–93; Warren Haag 2005, p. 1394). Tailings (the materials left over after extracting the desirable component of an ore) pond failures have also impacted aquatic resources (Powell River, Virginia; Butler 2007, p. 83). A decline of the snuffbox and other imperiled mussels in the Powell River was blamed on coalmining impacts (Ahlstedt and Tuberville 1997, p. 75). Increased

mining activities in the upper Clinch River system are resulting in ‘‘blackwater’’ events (Jones and Neves 2004, p. 2). Anecdotal evidence suggests that coal fines (very small coal particles) are increasing in the Clinch River reach that harbors a stronghold snuffbox population (Butler 2007, p. 84). A coalfired power plant planned for the upper Clinch River in Virginia would further increase mining in the Clinch and Powell watersheds.

Stressor: Channelization and dredging
Exposure:
Response:
Consequence:
Narrative: Dredging and channelization activities have profoundly altered riverine habitats nationwide. Hartfield (1993, pp. 131–141), Neves et al. (1997, pp. 71–72), and Watters (2000, pp. 268–269) reviewed the specific effects of channelization on freshwater mollusks. Channelization impacts a stream’s physical (accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, and riparian canopy loss) and biological (decreased fish and mussel diversity, changed species composition and abundance, decreased biomass, and reduced growth rates) characteristics (Hartfield 1993, p. 131; Hubbard et al. 1993, pp. 136–145). Channel construction for navigation has been shown to increase flood heights (Belt 1975, p. 189). This is partially attributed to a decrease in stream length and increase in gradient (Hubbard et al. 1993, p. 137). Flood events may thus be exacerbated, conveying into streams large quantities of sediment, potentially with adsorbed contaminants. Channel maintenance may result in profound impacts downstream (Stansbery 1970, p. 10), such as increases in turbidity and sedimentation, which may smother benthic (bottom-dwelling) organisms such as the rayed bean and snuffbox.

Stressor: Inadequacy of existing regulatory mechanisms
Exposure:
Response:
Consequence:
Narrative: At the time of listing, the inadequacy of existing regulatory mechanisms was considered to be a threat to the species. Inconsistent enforcement of current Federal and state laws to prevent sediment entering waterways causes risk to the rayed bean. Best management practices for sediment and erosion control are often recommended or required by local ordinances for construction projects; however, compliance, monitoring, and enforcement of these recommendations are often poorly implemented. Furthermore, prior to listing, there were no requirements within the scope of Federal environmental laws to specifically consider the rayed bean during Federal activities, or to ensure that Federal projects would not jeopardize their continued existence. Point source discharges within the range of the rayed bean have been reduced since the inception of the Clean Water Act (33 U.S.C. 1251 et seq.), but due to a lack of information it is unclear if these regulatory mechanisms provide adequate protection for filter-feeding organisms that can be impacted by extremely low levels of contaminants. There is no specific information on the sensitivity of the rayed bean to common industrial and municipal pollutants and very little information on other freshwater mussels. Despite these existing regulatory mechanisms, however, the rayed bean continued to decline prior to listing due to the effects of habitat destruction, poor water quality, contaminants, and other factors. In the listing rule, we found that these regulatory measures had been insufficient to significantly reduce or remove the threats to the rayed bean and, therefore, that the inadequacy of existing regulatory mechanisms is a threat to this species throughout all of its range. This analysis considers only non-ESA regulatory mechanisms. Since the species was listed, there have been seven projects

that have had the potential to impact rayed bean populations. Three of these projects were subsequently modified to avoid all instream effects, thereby avoiding adverse effects to the rayed bean and the need for consultation with the Service. Instream effects could not be avoided for four projects due to the nature of these project which required instream work. Through consultation with the local Service Field Offices, rayed bean were relocated out of harm's way for these four projects as a conservation measure for the species. This information indicates that were the species not listed, these projects would have had greater effect on the species, further demonstrating the inadequacy of existing non-ESA regulatory mechanisms (USFWS, 2018).

Recovery

Reclassification Criteria:
Not available

Recovery Priority Number: 5

Delisting Criteria:
The rayed bean may be considered for delisting when there are at least 20 populations (i.e., HUC 8 watersheds) in High condition with Moderate or Low risk, or in Moderate condition with Low risk (conditions and risk categories are defined in Service 2022a, Tables 4.3 and 4.4 or the most recent version of that document) range wide with the following distribution: Great Lakes Basin: At least 6 populations. Ohio Basin: At least 8 populations. Great Lakes, Ohio, and/or Tennessee: At least 6 additional populations. (USFWS, 2024).

Recovery Actions:
- 1. Manage, protect, and enhance existing and potential habitat: A) Creating and implementing habitat conservation measures (e.g., restoring and enhancing riparian buffers, populationspecific adaptive land management and protection plans, land acquisition, improving connectivity) around existing populations and potential reintroduction sites. B) B) Creating and implementing best management practices that avoid or minimize impacts to populations or their habitat (e.g., reduce detrimental inputs such as contaminants and sedimentation, suitable dam flow management). C) Maintaining and enhancing in-stream habitat at existing populations and at potential reintroduction sites. D) Monitoring habitat restoration projects and refine techniques using adaptive management. E) Researching habitat requisites and best management practices to maintain or restore populations. F) Restoring and improving connectivity between occupied stream reaches and between areas of suitable habitat (e.g., fish passage, dam removal).
- 2. Assess population and habitat status through monitoring and surveys: A) Including, but not limited to developing and implementing rigorous standardized methods to monitor population health, habitat, and threats at existing and reestablished populations. B) Investigating the species' status and the habitat condition in historical streams or where status is unknown to determine suitability for reintroductions or augmentations. C) Researching ways to improve the effectiveness of monitoring techniques (e.g., eDNA survey techniques).
- 3. Manage, protect, and enhance populations: A) Augmenting existing populations through captive-rearing techniques in accordance with propagation plans with considerations for genetics and disease. B) Restoring historical populations, as feasible, through reintroductions or translocations (e.g., using captive-bred individuals) in accordance with

propagation plans with considerations for genetics and disease. C) Developing and refining collection, propagation, culture, and release techniques. D) Researching biological, ecological, genetic, and life-history requisites to maintain or restore (e.g., stocking densities, post-relocation movement) populations.

- 4. Increase understanding of threats and alleviate threats into the foreseeable future: A) Researching the effects of climate change (e.g., changes in hydrological regime, stream morphology, stream temperatures) on the species, and determine and implement measures to alleviate those effects. B) Researching the effects of water quality parameters (e.g., contaminants, sedimentation, nutrients) and determine and implement measures to alleviate negative effects. C) Researching the effects of interacting and emerging threats and determine and implement measures to alleviate those effects. D) Determining the extent and effects of invasive species and how to alleviate those effects. E) Researching the possible causes of unexpected mass and species-specific mussel die-off events.
- 5. Engage the public and partners in freshwater mussel conservation: A) Developing outreach and education products and events to raise awareness and garner support for freshwater mussel conservation at local and regional levels. B) Disseminating targeted outreach to relevant partners and communities. C) Integrating planning and coordination among recovery partners. D) Engaging Federal agencies in proactive conservation actions to help fulfill their recovery obligations under section 7(a)(1) of the Act.

References

Final Listing Rule and status of the species provided by field office on sharepoint

final listing rule and the status of the species document that the FO provided on the sharepoint site

Status of the species that the field office provided on the sharepoint site U.S. Fish and Wildlife Service. 2018. Rayed Bean (Villosa fabalis). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region Ecological Services Field Office. Columbus, Ohio. 26 pp. USFWS. 2023. Rayed Bean (Villosa fabalis) Status Review: Summary and Evaluation. USFWS, Ohio Ecological Services Field Office Columbus, Ohio. 11 pages.

Final listing rule

U.S. Fish and Wildlife Service. 2018. Rayed Bean (Villosa fabalis). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region Ecological Services Field Office. Columbus, Ohio. 26 pp.

U.S. Fish and Wildlife Service. 2018. Rayed Bean (Villosa fabalis). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region Ecological Services Field Office. Columbus, Ohio. 26 pp.

USFWS. 2024. Recovery Plan for Four Species of Freshwater Mussels: Rayed Bean (Villosa fabalis), Sheepnose (Plethobasus cyphyus), Snuffbox (Epioblasma triquetra), and Spectaclecase (Cumberlandia monodonta). Bloomington, Minnesota. 16 pp.

SPECIES ACCOUNT: *Villosa perpurpurea* (Purple bean)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The purple bean is a freshwater mussel that has a small to medium-sized shell. The periostracum is usually dark brown to black with numerous closely spaced fine green rays. The nacre is purple, but the purple may fade to white in dead specimens.

Taxonomy

Villosa perpurpurea most closely resembles V. trabalis [(Conrad, 1834), Cumberland bean]. The most obvious difference is the purple nacre of the former in comparison to the white nacre of the latter.

Historical Range

This species has apparently been extirpated from the Powell River, North Fork Holston River, Emory River, Daddys Creek, and North Fork Beech Creek. Although tenuous, extant populations still occur in isolated portions of the Clinch River, Tazewell, Russell, and Scott Counties, Virginia; Indiana Creek, Tazewell County, Virginia; Copper Creek, Scott County, Virginia; Obed River, Cumberland County, Tennessee; and Beech Creek, Hawkins County, Tennessee.

Current Range

The purple bean is endemic to the upper Tennessee River system above its confluence with the Clinch River. Primarily a species of the Ridge and Valley Physographic Province, it also occurs at the eastern edge of the Cumberland Plateau. The entire range fo the purple bean occurs in northern Tennessee and sourthwestern Virginia.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 8/31/2004.

Legal Description

On August 31, 2004, the U.S. Fish and Wildlife Service (Service), designated river and stream segments (units) in the Tennessee and/or Cumberland River Basins as critical habitat for the purple bean (Villosa perpurpurea) under the Endangered Species Act of 1973, as amended (69 FR 53136 - 53180).

Critical Habitat Designation

Critical habitat is designated for the purple bean in Obed River (Unit 3), TN; Powell River (Unit 4), TN, VA; Clinch River (Unit 5), TN, VA; Copper Creek (Unit 5), VA; Indian Creek (Unit 5), VA; and Beech Creek (Unit 7), TN.

Unit 3. Obed River, Cumberland and Morgan Counties, Tennessee. Unit 3 encompasses 40 rkm (25 rmi) and begins at the confluence of the Obed River with the Emory River, Morgan County, Tennessee, and continues upstream to Adams Bridge, Cumberland County, Tennessee. This unit currently contains a population of the purple bean (Gordon 1991; S.A. Ahlstedt, pers. comm. 2002) and is also within designated critical habitat for the federally listed spotfin chub (see ''Existing Critical Habitat'' and Table 3). Unit 3 is located within the Obed National Wild and Scenic River (ONWSR), a unit of the NPS, and the Catoosa Wildlife Management Area (CWMA), which is owned by the TWRA.

Unit 4. Powell River, Claiborne and Hancock Counties, Tennessee, and Lee County, Virginia. Unit 4 encompasses 154 rkm (94 rmi) and includes the Powell River from the U.S. 25E Bridge in Claiborne County, Tennessee, upstream to rkm 256 (rmi 159) (upstream of Rock Island in the vicinity of Pughs), Lee County, Virginia. This reach is currently occupied by the Cumberlandian combshell (Ahlstedt 1991b; Gordon 1991) and rough rabbitsfoot (Service 2004), and was historically occupied by the oyster mussel (Wolcott and Neves 1990) and the purple bean (Ortmann 1918). It is also existing critical habitat for the federally listed slender chub and yellowfin madtom.

Unit 5. Clinch River and tributaries, Hancock County, Tennessee, and Scott, Russell, and Tazewell Counties, Virginia. Unit 5 totals 272 rkm (171 rmi), including 242 rkm (148 rmi) of the Clinch River from rkm 255 (rmi 159) immediately below Grissom Island, Hancock County, Tennessee, upstream to its confluence with Indian Creek in Cedar Bluff, Tazewell County, Virginia; 4 rkm (2.5 rmi) of Indian Creek from its confluence with the Clinch River upstream to the fourth Norfolk Southern Railroad crossing at Van Dyke, Tazewell County, Virginia; and 21 rkm (13 rmi) of Copper Creek from its confluence with the Clinch River upstream to Virginia State Route 72, Scott County, Virginia. The Clinch River main stem currently contains the oyster mussel, rough rabbitsfoot, Cumberlandian combshell, and purple bean (Gordon 1991; Ahlstedt and Tuberville 1997; S.A. Ahlstedt, pers. comm. 2002). Indian Creek currently supports populations of the purple bean and rough rabbitsfoot (Winston and Neves 1997; Watson and Neves 1996). Copper Creek is currently occupied by a low-density population of the purple bean and contains historical records of both the oyster mussel and rough rabbitsfoot (Ahlstedt 1981; Fraley and Ahlstedt 2001; S.A. Ahlstedt, pers. comm. 2003). Copper Creek is critical habitat for the yellowfin madtom and a portion of the Clinch River main stem section is critical habitat for both the slender chub and the yellowfin madtom.

Unit 7. Beech Creek, Hawkins County, Tennessee. Unit 7 encompasses 23 rkm (14 rmi) and extends from rkm 4 (rmi 2) of Beech Creek in the vicinity of Slide, Hawkins County, Tennessee, upstream to the dismantled railroad bridge at rkm 27 (rmi 16). It supports the best remaining population of purple bean and the only remaining population of any of these species in the Holston River drainage (Ahlstedt 1991b; S.A. Ahlstedt, pers. comm. 2002).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of the purple bean (Villosa perpurpurea) are those habitat components that support feeding, sheltering, reproduction, and physical features for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Permanent, flowing stream reaches with a flow regime (i.e, the magnitude, frequency, duration, and seasonality of discharge over time) necessary for normal behavior, growth, and survival of all life stages of the five mussels and their host fish;

(ii) Geomorphically stable stream and river channels and banks;

(iii) Stable substrates consisting of mud, sand, gravel, and/or cobble/ boulder, with low amounts of fine sediments or attached filamentous algae;

(iv) Water quality (including temperature, turbidity, oxygen content, and other characteristics) necessary for the normal behavior, growth, and survival of all life stages of the five mussels and their host fish; and

(v) Fish hosts with adequate living, foraging, and spawning areas for them.

Special Management Considerations or Protections

All critical habitat units identified may require special management considerations or protection to maintain geomorphic stability, water quantity or quality, substrates, or presence of fish hosts. All of these units are threatened by actions that alter the stream slope (e.g., channelization, instream mining, impoundment) or create significant changes in the annual water or sediment budget (e.g., urbanization, deforestation, water withdrawal); and point and/or nonpoint source pollution that results in contamination, nutrification, or sedimentation. Habitat fragmentation, population isolation, and small population size compounds threats to this species.

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: Gravid females of the purple bean, another lampsiline, have been observed in January and February (Ahlstedt 1991a; Butler, pers. obs., 2001), and they release their glochidia in May and June (Watson 1999). The smallest gravid individual found in a study in Indian Creek was 1.5 inches (Watson 1999). The length of the glochidia is 0.005 inch, and the width is 0.007 inch (Watson 1999). At least four host fish species have been identified--the fantail darter (Etheostoma flabellare), greenside darter, black sculpin, and mottled sculpin and/or banded sculpin (Watson and Neves 1996, Watson 1999; Jones, letter dated June 9, 2003). Transformation took from 11 to 25 days, at 70.7° to 76.1°F.

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: antail darter (Etheostoma flabellare), greenside darter, black sculpin, and mottled sculpin and/or banded sculpin

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: Adult mussels are ideally found in localized patches (beds) in streams, almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Vannote and Minshall 1982, Neves and Widlak 1987, Leff et al. 1990, Strayer 1997). Physical qualities of the sediment (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediment, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999). Water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams (Huehner 1987). The Purple bean inhabits small headwater streams (Neves 1991) to medium-sized rivers (Gordon 1991). It is found in moderate to fast-flowing riffles with sand, gravel, and cobble substrates (Neves 1991) and rarely occurs in deep pools or slack water (Ahlstedt 1991a). It is sometimes found out of the main current adjacent to water-willow beds and under flat rocks (Ahlstedt 1991a, Gordon 1991).

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
unknown

Population Size:
50 - 1000 individuals

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The decline, extirpation, and extinction of mussel species is overwhelmingly attributed to habitat alteration and destruction (Neves 1993), primarily manifest in the conversion of riverine systems to impoundments (Yeager 1993 1994). Impoundments, especially large main-stem reservoirs, have significantly altered riverine ecosystems (Baxter and Glaude 1980, Williams et al. 1992, Allan and Flecker 1993, Ligon et al. 1995, Sparks 1995) and have been a major factor in the high extinction rate oof freshwater mollusks (Johnson 1978, Lydeard and Mayden 1995, Neves et al. 1997). Impoundments result in the elimination of riffle and shoal habitats and the subsequent loss of mussel resources (Ortmann 1925; van der Schalie 1938; Scruggs 1960; Bates 1962; Neel 1963; Isom 1969, 1971; Stansbery 1970, 1973b; Fuller 1974; Schmidt et al. 1989; Williams et al. 1992; Layzer et al. 1993; Parmalee and Hughes 1993; Lydeard and Mayden 1995; Sickel and Chandler 1996; Watters 1996). Most of a river's ecological processes are also disrupted, for example, by modifying flood pulses; controlling impounded water elevations; increasing depth; decreasing habitat heterogeneity; altering water flow, sediment, nutrients, energy input and output, and the riverine biota; and causing the loss of bottom stability due to subsequent sedimentation (Williams et al. 1992, Ligon et al. 1995, Sparks 1995, Watters 2000). The elimination of current and the covering of rocky and sand substrates by fine sediments alters the habitat of riverine species (including these five, typically shoal-inhabiting, species) to the point where they can no longer reproduce, recruit, and survive under impoundment conditions (Fuller 1974, Neves et al. 1997, Hughes and Parmalee 1999). In addition, dams can seriously alter downstream water quality and riverine habitat (Allan and Flecker 1993, Ligon et al. 1995, Collier et al. 1996) and negatively impact mussel populations in tailwaters (Cahn 1936b, Hickman 1937,

Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999, McMurray et al. 1999b, Vaughn and Taylor 1999). These changes include thermal alterations (Neves 1993), channel characteristics, habitat availability, and flow regimes that have drastic effects on the stream biota (Krenkel et al. 1979, Allan and Flecker 1993). Altered effects also include fish community shifts (Brim 1991) and the resultant colonization by fewer native species and more alien species (Williams and Neves 1992). Daily discharge fluctuations, bank sloughing, seasonal oxygen deficiencies, cold-water releases, turbulence, high silt loads, and altered host fish distribution have contributed to limited mussel recruitment and skewed demographics (Sickel 1982, Ahlstedt 1983, Miller et al. 1984, Layzer et al. 1993, McMurray et al. 1999b). Cold-water releases from large nonnavigational dams are the result of placing water intake structures low on the dam to increase hydropower efficiency (Krenkel et al. 1979). The release of cold water and scouring of the riverbed from highly fluctuating, turbulent flows in tailwaters have also been implicated in the demise of Cumberlandian Region mussel faunas (Miller et al. 1984, Layzer et al. 1993, Heinricher and Layzer 1999). Specifically, tachytictic species, which depend on warm summer temperatures to initiate gametogenesis, spawning, glochidia release, and the proper host fish being present, experience reproductive failure below dams (Heinricher and Layzer 1999). Bradytictic species are also negatively affected, and the decline of mussel populations has been manifested over a period of several decades (Neves 1999a). The mussel faunas of the middle Cumberland, lower Obey, lower Caney Fork, Little Tennessee, and Elk Rivers have been profoundly impacted by cold-water releases, including populations of the Cumberlandian combshell and oyster mussel. A reduction in water temperature, rapid changes in flow releases during hydropower peaking events, and the resultant bank sloughing and channel scouring have altered habitats so profoundly below hydroelectric dams that riverine species, including these five mussels, are unable to reproduce, recruit, and survive such conditions. The entire length of the main stems of the Tennessee and Cumberland Rivers and many of their largest tributaries are now impounded or greatly modified by the discharge of tailwaters. More than 2,300 river miles (about 20 percent) of the Tennessee River and its tributaries with drainage areas of 25 square miles or greater were impounded by the TVA by 1971 (TVA 1971). The subsequent completion of additional major impoundments on tributary streams (e.g., Duck River in 1976, Little Tennessee River in 1979) significantly increased the total miles impounded behind the 36 major dams in the Tennessee River system (Neves et al. 1997). Approximately 90 percent of the 562-mile length of the Cumberland River downstream of Cumberland Falls is either impounded (three locks and dams and the Wolf Creek Dam) or otherwise adversely impacted by cold-water discharges from the Wolf Creek Dam. Miller et al. (1984) located only two mussel specimens in a survey below the Wolf Creek Dam, which covered 68 miles of river that formerly harbored 39 species (Neel and Allen 1964). Other major U.S. Army Corps of Engineers (COE) impoundments on Cumberland River tributaries (e.g., Laurel River, Obey River, Caney Fork, Stones River) have inundated more than 125 miles of potential riverine habitat for the Cumberland elktoe, oyster mussel, and Cumberlandian combshell. Impoundments, as barriers to dispersal, contribute to the loss of local populations by blocking postextirpation recolonization (Luttrell et al. 1999). Population losses due to impoundments have probably contributed more to the decline of the Cumberlandian combshell, oyster mussel, and rough rabbitsfoot and most other Cumberlandian Region mussels than any other single factor (as the Cumberland elktoe and purple bean generally inhabit smaller rivers, impoundments have had less of an impact on them). Stream populations of these species thought to have been lost primarily or exclusively due to impoundments include the Cumberland River, Laurel River, Lynn Camp Creek, Rockcastle River, Beaver Creek, Obey River, Caney Fork, and Stones River in the Cumberland River system; and the South Fork Holston River, Holston River, Tennessee River, Little Tennessee River, Hiwassee River, Limestone Creek, Elk River, and

Shoal Creek in the Tennessee River system. Reaches in other streams with extant populations of some of these species have also been destroyed by impoundments that invariably eliminated expanses of their occupied habitat (e.g., lower Big South Fork in the Cumberland River system; lower French Broad River, lower Little River [Tennessee], lower Clinch River, lower Powell River, lower Emory River, upper and lower Bear Creek, middle Duck River in the Tennessee River system). The majority of the extant populations of these species have been isolated due to impoundments (see “Patterns of Imperilment,” “Narrative Outline,” and Recovery Task 1.4.6 for a discussion of the consequences of population fragmentation), and some continue to decline and die off.

Stressor: Dredging and channelization
Exposure:
Response:
Consequence:
Narrative: Dredging and channelization activities have profoundly altered riverine habitats nationwide, with effects on streams summarized by Simons (1981), Bhowmik (1989), and Hubbard et al. (1993). DeHaan (1998) provided an annotated bibliography of sediment transport and deposition in large rivers. Hartfield (1993) and Neves et al. (1997) reviewed the specific effects of channelization on freshwater mollusks. Channelization impacts a stream’s physical (e.g., accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, riparian canopy loss) and biological (e.g., decreased fish and mussel diversity, changed species composition and abundance, decreased biomass and growth rates) characteristics (Stansbery and Stein 1971, Hartfield 1993, Hubbard et al. 1993). Since mussels need stable substrates to survive (Strayer 1999a), channel instability is probably the single most detrimental aspect of channelization (Hartfield 1993). Channel construction for navigation has been shown to increase flood heights (Belt 1975), thus exacerbating flood events that convey to streams large quantities of sediment with adsorbed contaminants. Channel maintenance may also result in downstream impacts (Stansbery 1970), such as increases in turbidity and sedimentation, which may smother benthic organisms. Impacts associated with barge traffic--the construction of fleeting areas, mooring cells, docking facilities, and propeller wash--also disrupt habitat. Although the volume of literature demonstrating the on-site and off-site environmental and economic consequences of dredging for navigation and flood control is substantial (Smith and Patrick 1991, Watters 2000), these activities continue in the Southeast. The entire length of the Tennessee River and much of the Cumberland River is maintained as a navigation channel with a series of locks and dams--nine on the Tennessee River and four on the Cumberland River. Although the dams themselves probably contributed more to the destruction of riverine habitat for mussels (including the oyster mussel and Cumberlandian combshell), channel maintenance activities continue to cause substrate instability and alteration in these rivers and may serve to diminish what habitat remains for the recovery of riverine species. Other streams, notably the lower Paint Rock River (Ahlstedt 1995-96) and portions of the Bear Creek system (McGregor and Garner, in press), have been channelized, primarily during ill-fated attempts to reduce flooding.

Stressor: Mineral extraction
Exposure:
Response:
Consequence:
Narrative: Mineral extraction: Heavy metal-rich drainage from coal mining and associated sedimentation have adversely impacted many stream reaches (Barnhisel and Massey 1969,

Ahmad 1973, Curry and Fowler 1978), destroying mussel beds and preventing natural recolonization (Simmons and Reed 1973, McCann and Neves 1992). Neves et al. (1997) reviewed the effects of various mining activities on freshwater mollusks. The low pH commonly associated with mine runoff can lead to an inability of glochidia to clamp their valves on host tissues, thus preventing proper encystment (Huebner and Pynnönen 1992). Therefore, acid mine runoff may be having local impacts on the recruitment of, particularly, the Cumberland elktoe, since most of its range is within watersheds where coal mining is still occurring. In addition, interstitial spaces in streams, which is habitat critical for juvenile mussels, are clogged by sediment runoff from mines (Branson and Batch 1972). Circumstantial evidence indicates that salinity, a by-product of oil exploration activities, is lethal to some glochidia (Liquori and Insler 1985). Increased sedimentation and turbidity (see “Sedimentation,” in this section, for its effects on mussels), reduction in pH from chemicals associated with acid mine drainage, and heavy metals (see “Contaminants,” in this section, for their effects on mussels) have altered habitat in many streams to the point where mussels, including these species, are unable to reproduce, recruit, and survive these conditions. Impacts associated with coal mining activities have particularly altered upper Cumberland River system streams with diverse historical mussel faunas (Stansbery 1969, Blankenship 1971, Blankenship and Crockett 1972, Starnes and Starnes 1980, Schuster et al. 1989, Anderson et al. 1991) and have been implicated in the decline of Epioblasma species, especially in the Big South Fork (Neel and Allen 1964). Strip mining continues to threaten mussels in coal field drainages of the Cumberland Plateau (Anderson 1989, Warren et al. 1999) with increased sedimentation loads and acid mine drainage, including Cumberland elktoe and Cumberlandian combshell populations. The Marsh Creek population of the Cumberland elktoe has also been adversely affected and is still threatened by potential spills from oil exploration activities. Coal mining activities also occur in portions of the upper Powell and Clinch River systems, primarily in Virginia. Scores of active and inactive mines are known from these drainages (Hampson et al. 2000). Five mine tailings pond spills were reported from 1995 to 1999 in the upper Clinch and Powell River systems (Hampson et al. 2000), at least one of which resulted in a major fish kill (Koch, pers. comm., 1996). Research by Kitchel et al. (1981) indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981). Polycyclic aromatic compounds (PAHs) are indicative of coal fines in the bottom sediments of streams. Known to be toxic to mussels and fishes, PAHs have been found at relatively high levels in the upper portions of the Clinch and Powell Rivers in Virginia (Hampson et al. 2000). In fact, Hampson et al. (2000) detected 29 different PAHs in stream sediment samples in the two watersheds. The Clinch River at Pendleton Island had concentrations of two measured PAHs, naphthalene and phenanthrene, at 400 micrograms per kilogram (µg/kg) and 570 µg/kg, respectively, both of which are above the protection guidelines for aquatic life. The Canadian probable-effect levels of 391 µg/kg and 515 µg/kg, respectively, have been established for these compounds. The probable-effect levels define concentrations above which adverse effects to aquatic organisms can be expected. Pendleton Island was once a stronghold for the rough rabbitsfoot and home to the oyster mussel, Cumberlandian combshell, and purple bean as well in the early 1980s (Ahlstedt 1991a). However, the fauna there was in marked decline less than a decade later. No live oyster mussels or Cumberlandian combshells were found in 1987 (Dennis 1989). Three other sites in the Clinch River system (i.e., lower Clinch River, Guest River, Copper Creek) had concentrations of these two compounds below the probable-effect levels. A site on the Powell River near Arthur, Tennessee, had much higher levels of naphthalene and phenanthrene (1,600 µg/kg and 1,300 µg/kg, respectively) than at Pendleton Island. In the Emory River, downstream of a population of the purple bean in the Obed River, excessive naphthalene levels were detected (610 µg/kg). In a quantitative study in the Powell River, Ahlstedt and Tuberville (1997) attributed a 15-year decline of the oyster mussel, Cumberlandian combshell, and rough rabbitsfoot and the long-term decrease in species diversity (from 30 in 1979 to 21 in 1994) to general stream degradation due primarily to coal mining activities in the headwaters. Mining activities also likely contributed to the extirpation of the purple bean from the Powell River several decades ago. Iron and phosphate mining in the Duck River watershed was thought to have caused mussel declines in the early 1900s (Ortmann 1924a).

Stressor: Graving mining
Exposure:
Response:
Consequence:
Narrative: In-stream gravel mining has been implicated in the destruction of mussel populations (Stansbery 1970, Yokley and Gooch 1976, Grace and Buchanan 1981, Hartfield and Ebert 1986, Schuster et al. 1989, Hartfield 1993, Howard 1997). Lagasse et al. (1980), Kanehl and Lyons (1992), and Roell (1999) reviewed the physical and biological effects of mining sediment from streams. Negative impacts include riparian forest clearing (e.g., mine site establishment, access roads, lowered floodplain water table); stream channel modifications (e.g., geomorphic instability, altered habitat, disrupted flow patterns [including lowered elevation of stream flow], sediment transport); water quality modifications (e.g., increased turbidity, reduced light penetration, increased temperature); macroinvertebrate population changes (e.g., elimination, habitat disruption, increased sedimentation); and changes in fish populations (e.g., impacts to spawning and nursery habitat, food web disruptions). Once mussels have been eliminated, a decade or more may pass before recolonization occurs (Stansbery 1970, Grace and Buchanan 1981). Substrate disturbance and sedimentation impacts can also be realized for considerable distances downstream (Stansbery 1970), and possibly upstream (Hartfield 1993). Gravel mining activities threaten the Cumberlandian combshell populations in the Powell River and in Buck Creek, the latter stream representing one of only two remaining populations of this species in the entire Cumberland River system. Mining activities on the Elk River (Ahlstedt 1991b) may have played a role in the extirpation of the oyster mussel and Cumberlandian combshell from that river. Gravel removal was apparent at 12 sites along a 40-mile stretch of the lower Elk River during 1999 mussel sampling (Anonymous 1999). Activities that occur without a permit, unless controlled, may prevent the long-term reintroduction of some of the 13 federally listed mussels that are known from the Elk.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Contaminants contained in point and nonpoint discharges can degrade water and substrate quality and adversely impact, if not destroy, mussel populations (Horne and McIntosh 1979, Neves and Zale 1982, McCann and Neves 1992, Havlik and Marking 1987). Although chemical spills and other point sources (e.g., ditch, swale, artificial channel, drainage pipe) of contaminants may directly result in mussel mortality, widespread decreases in density and diversity may result, in part, from the subtle, pervasive effects of chronic low-level contamination (Naimo 1995). The effects of excessive concentrations of heavy metals and other contaminants on freshwater mussels were studied by Mellinger (1972), Fuller (1974), Havlik and Marking

(1987), Naimo (1995), Keller and Lydy (1997), and Neves et al. (1997). Mussels appear to be among the most intolerant organisms to heavy metals (Keller and Zam 1991), several of which are lethal, even at relatively low levels (Havlik and Marking 1987). Cadmium appears to be the heavy metal most toxic to mussels (Havlik and Marking 1987), although chromium, copper, mercury, and zinc also negatively affect biological processes (Jacobson et al. 1993, Naimo 1995, Keller and Zam 1991, Keller and Lydy 1997). In laboratory experiments, mussels suffered mortality when exposed to 2.0 parts per million (ppm) cadmium, 12.4 ppm chromium, 19.0 ppm copper, and 66.0 ppm zinc (Mellinger 1972, Havlik and Marking 1987). Most metals are persistent in the environment (Miettinen 1977), remaining available for uptake, transportation, and transformation by organisms for long periods (Hoover 1978). Highly acidic pollutants such as metals are capable of contributing to mortality by dissolving mussel shells (Stansbery 1995). Among other pollutants, ammonia has been shown to be lethal to mussels at concentrations of 5.0 ppm (Havlik and Marking 1987). Ammonia is oftentimes associated with animal feedlots, nitrogenous fertilizers, and the effluents of older municipal wastewater treatment plants (Goudreau et al. 1993). This contaminant may become more problematic for juvenile mussels during periods of low flow, when water temperatures increase (Newton et al. 2003b). In stream systems, ammonia is most prevalent at the substrate/water interface (Frazier et al. 1996). Due to its high level of toxicity and the fact that the highest concentrations occur in the microhabitat, where mussels live, ammonia should be considered among the factors potentially limiting the survival and recovery of mussels at some locations (Augspurger et al., in press). Certain adult species may tolerate short-term exposure (Keller 1993). However, the effects of heavy metals and other toxicants are especially profound on juvenile mussels (Robison et al. 1996) and on the glochidia, which appear to be very sensitive to toxicants such as ammonia (Goudreau et al. 1993). Low levels of some metals may inhibit glochidial attachment (Huebner and Pynnönen 1992). Juvenile mussels may inadvertently ingest contaminated silt particles while feeding . Mussel recruitment may therefore be reduced in habitats with low but chronic heavy metal and other toxicant inputs (Yeager et al. 1994, Naimo 1995, Ahlstedt and Tuberville 1997), which may have contributed to the demise of these five species. Common contaminants associated with households and urban areas, particularly those from industrial and municipal effluents, may include heavy metals, ammonia, chlorine, phosphorus, and numerous organic compounds. Nonpoint-source runoff from urban areas tends to have the highest levels of many pollutants, such as phosphorus and ammonia, when compared to other catchments (Mueller et al. 1995). Wastewater is discharged at sites throughout the country with permits (and some without permits) issued by the National Pollution Discharge Elimination System (NPDES). Elimination sites are ubiquitous in watersheds containing rough rabbitsfoot populations, providing ample opportunities for some pollutants to enter streams. Collectively, pollutants from these sources may cause decreased dissolved oxygen levels, increased acidity, and other water chemistry changes that may be lethal to mussels (Horne and McIntosh 1979, Rand and Petrocelli 1985, Sheehan et al. 1989, Keller and Zam 1991, Dimock and Wright 1993, Goudreau et al. 1993, Jacobson et al. 1993, Keller 1993). Sediment from the upper Clinch River, where several of these species occur, was found to be toxic to juvenile mussels (Robison et al. 1996). Ahlstedt and Tuberville (1997) speculated that the presence of toxins in the Clinch River may explain the decline and lack of mussel recruitment at some sites in the Virginia portion of that stream. Wilcove and Bean (1994) reported that studies indicated that mussel reproduction below the site of the Appalachian Power Company's (APCO) electric generating station in Carbo, Virginia, was being inhibited by copper discharges. In addition, copper was shown to be toxic to mussels at levels below the U.S. Environmental Protection Agency (EPA) criteria established in Virginia. The Virginia State Water Control Board began proceedings to impose a special water quality standard for copper below the plant. In 1992, the State and APCO agreed on a lower standard for copper for this specific stretch of the Clinch. APCO is spending several million dollars to control copper discharge from its facility to meet the new standard (Wilcove and Bean 1994). Although the Clean Water Act (CWA), administered by the EPA, has helped eliminate many point-source effluents, “straight pipes” (pipelines conveying untreated household effluents; e.g., chlorine, detergents, household chemicals, human waste, etc., from rural homes directly into streams) continue to discharge wastes. Fraley and Ahlstedt (2000) thought that effluents from straight pipes were partially to blame for the documented decline of the native mussel fauna in Copper Creek from 19 species in 1980 to 11 species in 1998. Included in the historical Copper Creek fauna were the oyster mussel, rough rabbitsfoot, and purple bean, although only the latter species was found live in 1998. Numerous other streams in the Cumberlandian Region doubtless also have straight pipes discharging pollutants into mussel habitat. Agricultural sources of chemical contaminants are considerable and include two broad categories--nutrients and pesticides (Frick et al. 1998). Nutrient enrichment generally occurs as a result of runoff from livestock farms and feedlots and from fertilizers used on row crops. Various OWCs may also be associated with livestock concentrations (Kolpin et al. 2002). Nitrate concentrations are particularly high in surface waters downstream of agricultural areas (Mueller et al. 1995). Stream ecosystems are impacted when nutrients are added at concentrations that cannot be assimilated, resulting in overenrichment, a condition exacerbated by low-flow conditions. Excessive stands of filamentous algae, a common manifestation of overenrichment, alter the surface of the stream bottom and may represent a shift in algal communities that could disrupt, particularly, juvenile mussel food supplies. Juvenile mussels, utilizing interstitial habitats, are particularly affected by excessive levels of algae-consuming dissolved oxygen during nocturnal respiration (Sparks and Strayer 1998). Increased risks from bacterial and protozoan infections to eggs and glochidia may also pose a threat (Fuller 1974). Hoos et al. (2000) summarized data on nutrient loading in the lower Tennessee River system, where overenrichment was the cause of impairment in 37 stream segments. Nonpoint sources, primarily agricultural inputs, accounted for the largest percentage of total nitrogen and total phosphorus in all streams tested in the study area. Relatively high levels of nutrients were prevalent in the Duck River, where a large population of the oyster mussel occurs. Nutrient levels were also analyzed in the upper Tennessee River system by Hampson et al. (2000). Overall, nutrient concentrations were generally lower than national concentrations and were relatively high only on a localized scale. Secondly, pesticides, primarily from row crops, are a major s

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Sedimentation is widely thought to have contributed to the decline of mussel populations (Kunz 1898; Ellis 1931, 1936; Cordone and Kelly 1961; Imlay 1972; Coon et al. 1977; Marking and Bills 1979; Wilber 1983; Dennis 1985; Schuster et al. 1989; Wolcott and Neves 1990; Houp 1993; Richter et al. 1997, Brim Box 1999; Henley et al. 2000; Fraley and Ahlstedt 2000). Specific biological impacts on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity, and physical smothering (Ellis 1936, Stansbery 1971, Markings and Bills 1979, Kat 1982, Vannote and Minshall 1982, Aldridge et al. 1987, Waters 1995). Brim Box (1999) showed that burying adult mussels under 5.5 inches of sediment in the Apalachicola, Chattahoochee, and Flint River basin significantly decreased their

chances of surviving. Intuitively, much thinner layers of sediment may result in juvenile mortality. Some studies tend to indicate that the primary impacts of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999). The physical effects of sediment on mussels appear to be multifold (Brim Box and Mossa 1999). They are potentially impacted by changes in suspended and bed material load; bed sediment composition associated with increased sediment production and runoff in the watershed; channel changes in form, position, and degree of stability; changes in depth or the width/depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave them high and dry (Vannote and Minshall 1982, Kanehl and Lyons 1992, Hartfield 1993, Brim Box and Mossa 1999; see earlier discussion on "Gravel Mining"). Interstitial spaces in mixed substrates may become clogged with sediment (Gordon et al. 1992). When clogged, interstitial flow rates and spaces may become reduced (Brim Box and Mossa 1999), thus reducing habitat for juvenile mussels and some adults as well. Salomons et al. (1987) and the National Research Council (1992) indicated that sediment may act as a vector for delivering contaminants such as nutrients and pesticides to streams. Juveniles can readily ingest contaminants adsorbed to silt particles during normal feeding activities. These factors may help explain, in part, why so many mussel populations appear to be experiencing recruitment failure. Host fish/mussel interactions may be indirectly impacted by changes in stream sediment regimes through three mechanisms (Brim Box and Mossa 1999). First, fish abundance (Berkman and Rabeni 1987), diversity (Waters 1995), and reproduction (Muncy et al. 1979) may be reduced with increased sedimentation. Second, excessive sedimentation likely impedes host fish attractant mechanisms (e.g., mantle flaps, conglutinates, superconglutinates that mimic fish prey item (Haag et al. 1995, Burkhead et al. 1997). Third, sedimentation on shoal substrates may interfere with the ability of some species' adhesive conglutinates to adhere to rock particles (Hartfield and Hartfield 1996). Many Southeastern streams have increased turbidity levels due to siltation (van der Schalie 1938). Some of these five species attract host fishes with visual cues, luring fish into perceiving that their glochidia are prey items (see "Reproductive Biology of the Five Species"). Such a reproductive strategy depends on clear water during the critical time of the year when mussels are releasing their glochidia (Hartfield and Hartfield 1996). Turbidity is a limiting factor impeding sight-feeding fishes (Burkhead and Jenkins 1991) and may have contributed to population declines in some of these mussel species. In addition, mussels may be indirectly affected when turbidity levels significantly reduce the amount of light available for photosynthesis and the production of unionid food items (Kanehl and Lyons 1992). Agricultural activities produce the most significant amount of sediment that enters streams (Waters 1995). Neves et al. (1997) stated that agriculture (including both sediment and chemical runoff) affects 72 percent of the impaired river miles in the country. Unfortunately, the CWA does not regulate agricultural runoff, return waters, or discharge flows (D. Powell, EPA, letter dated June 20, 2003). Armour et al. (1991) reviewed the effects of livestock grazing on riparian and stream ecosystems. Unrestricted access by livestock is a significant threat to streams (Trimble and Mendel 1995) and their mussel populations throughout much of the Cumberlandian Region (Anonymous 1999, Fraley and Ahlstedt 2000). Grazing may reduce infiltration rates and increase runoff and erosion (Brim Box and Mossa 1999). Trampling causes or accelerates stream-bank erosion, and grazing reduces a bank's resistance to erosion (Armour et al. 1991, Trimble and Mendel 1995). In addition, livestock may add nutrients to streams at levels that are not easily assimilated, particularly during low-flow conditions, resulting in overenrichment. Fraley and Ahlstedt (2000) attributed the decline of the Copper Creek mussel fauna between 1980 and 1998, among other factors, to an increase in cattle grazing and loss of riparian vegetation in the stream. They considered the oyster mussel and rough rabbitsfoot as possibly being extirpated from Copper Creek. Erosion from silvicultural activities accounts for 6 percent of the nation's sediment pollution (Henley et al. 2000). Sedimentation impacts are more the result of logging roads than the actual harvesting of timber (Waters 1995, Brim Box and Mossa 1999).

Stressor: Urban Development
Exposure:
Response:
Consequence:
Narrative: Developmental activities associated with urbanization (e.g., highways, building construction, infrastructure creation, recreational facilities) may contribute significant amounts of sediment and other pollutants in quantities that may be detrimental to stream habitats (Waters 1995, Couch and Hamilton 2002). Urban development changes sediment regimes by creating impervious surfaces and drainage system installations (Brim Box and Mossa 1999). The highest erosion rates are generally associated with construction activities, which can contribute sediment at a rate 300 times greater than from forested land (USDA 1977). Stream channel erosion contributes up to two-thirds of the total sediment yield in urbanized watersheds (Trimble 1997). With development, watersheds become more impervious, resulting in increased storm-water runoff into streams (Myers-Kinzie et al. 2002) and a doubling in annual flow rates in completely urbanized streams (DeWalle et al. 2000). Impervious surfaces may reduce sediment input into streams but result in channel instability by accelerating storm-water runoff, which increases bank erosion and bed scouring (Brim Box and Mossa 1999). Stream channels become highly unstable as they respond to increased flows by incising, which increases shear stress and bed mobilization (Doyle et al. 2000). With increasing shear stress, benthic organisms become increasingly dislodged downstream (Myers-Kinzie et al. 2002). Studies have indicated that high shear stress is associated with low mussel densities (Layzer and Madison 1995) and that peak flows and substrate movement limits mussel communities, particularly at the juvenile stage (Myers-Kinzie et al. 2002). For some of these species, a considerable amount of habitat has been lost, particularly in metropolitan areas in Tennessee (e.g., Knoxville, Nashville, Chattanooga). Streams that contain these five species, and which are currently threatened with development activities, include Sinking Creek (potential interstate highway, industrial park; Cumberland elktoe) and Buck Creek (potential interstate highway, Cumberlandian combshell), Kentucky; Bear Creek, (instream gold mining, Cumberlandian combshell), Alabama and Mississippi; and the Duck River (general development from rapid growth, oyster mussel) Tennessee (Butler, pers. obs., 2002; Cicerello, pers. comm., 2003; L. Colley, TNC, pers. comm., 2002). Water withdrawals for agricultural irrigation and municipal and industrial water supplies are an increasing concern for all aquatic resources and are directly correlated with expanding human populations. This impact has the potential to be a particular problem for the Cumberland elktoe population in the Big South Fork system and the oyster mussel population in the Duck River. Droughts may also be a threat to these species, particularly populations occurring in smaller streams. Impacts include decreased flow velocities and depressed dissolved oxygen levels (Johnson et al. 2001). Stochastic events, such as droughts, may be exacerbated by global warming and water withdrawals. These anthropogenic activities act insidiously to lower water tables, thus making mussel populations susceptible to depressed stream levels.

Stressor: Invasives
Exposure:
Response:

Consequence:
Narrative: The asian clam has been implicated as a competitor with native mussels for resources such as food, nutrients, and space (Heard 1977, Kraemer 1979, Clarke 1986), particularly as juveniles (Neves and Widlak 1987). According to Strayer (1999b), dense populations of Asian clams may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles. Periodic dieoffs may produce enough ammonia and consume enough oxygen to kill native mussels (Strayer 1999b). The invasion of the nonnative zebra mussel (Dreissena polymorpha [Pallas, 1773]) poses a threat to the mussel fauna of the Cumberlandian Region (Ricciardi et al. 1998). Zebra mussels in the Great Lakes have attached, in large numbers (up to 10,000 per unionid), to the shells of live and fresh dead native mussels (Schlosser and Kovalak 1991), and they have been implicated in the loss of mussel beds (Hunter and Bailey 1992, Masteller et al. 1993, Schlosser and Nalepa 1995). Although zebra mussels are now in the Tennessee and Cumberland River systems, the extent to which they will impact native mussels is unknown.

Recovery

Reclassification Criteria:
1) Four streams with distinct viable populations of the purple bean have been established. 2) One distinct naturally reproduced year class exists within each of the viable populations. 3) Research studies of the mussel's biological and ecological requirements have been completed and any required recovery measured developed and implemented from these studie sare beginning to be successful, as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring. 4) No foreseeable threats exist that would likely impact the survival of the species over a significant portion of its range. 5) Within larger streams, the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable. 6) Biennial monitoring yields the results outlined in criterion (1) above over a 10-year period.

Delisting Criteria:
1) Five streams with distinct viable populations of the purple bean have been established. 2) Two distinct naturally reproduced year class exists within each of the viable populations. 3) Research studies of the mussel's biological and ecological requirements have been completed and any required recovery measured developed and implemented from these studie sare beginning to be successful, as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring. 4) No foreseeable threats exist that would likely threaten the survival of any of the viable populations. 5) Within larger streams, the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable. 6) Biennial monitoring yields the results outlined in criterion (1) above over a 10-year period.

Recovery Actions:
- Continue to augment extent populations and where appropriate, repopulate extirpated populations via captive propagation

- Through various means of land protection (land acquisition, BMP Programs, conservation easements), abate non-point source impacts and direct habitat loss.
- Continue to use existing legislation and regulations to protect the species and its habitat.
- Pursue and establish protective criteria for known and suspected pollutants.
- Educate the public about impacts to habitat and water quality.
- Foster support for recovery through partnerships and landowner participation.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS - Based on our review of purple bean (= Tennessee bean), we believe the following measures are appropriate: • Revise the listing information, through the public rulemaking process, for the Cumberland bean and purple bean to reflect the current understanding of the taxonomy of these species. This includes both the rule to recognize the common name and scientific name changes and a rule updating the geographic extent of both species. • Subsequent to the revisions described above, update the recovery plan for the species to incorporate the changes in known populations resulting from the revised taxonomy. • Continue to augment and expand extant populations through propagation of juveniles, and monitor fate of released individuals. • Establish long-term monitoring sites to track the status of populations and trends. • Reestablish viable populations in additional streams within the historical range that have suitable habitat and water quality conditions. The North Fork Holston River should be considered as a potential reintroduction site. • Through various means of land protection (land acquisition, best management practices [BMP] programs, conservation easements), abate nonpoint source impacts and direct habitat loss (addresses recovery action 1.3.3). • Inform the public about impacts to habitat and water quality (addresses recovery action 7.1) and how to avoid and remediate the impacts. (USFWS, 2020)

References

five year review

recovery plan

final rule for critical habitat

Nature Serve

U.S. Fish and Wildlife Service. 2004. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Endangered Mussels in the Tennessee and Cumberland River Basins. Final rule. 69 FR 53136 - 53180 (August 31, 2004).

Recovery Plan

USFWS. 2020. Purple Bean Villosa perpurpurea (= Tennessee Bean

Venustaconcha trabalis) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southwestern Virginia Field Office Abingdon, Virginia. 24 pp.

SPECIES ACCOUNT: *Villosa trabalis* (Cumberland bean (pearlymussel))

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 06/14/1976, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

The Cumberland bean is a small to medium-sized Cumberlandian freshwater mussel species with solid, elongate, inflated, oval valves. The beaks are relatively high with the surface of the shell unsculptured except for concentric growth rests, and beack sculpturing consisting of course, double-looped ridges. The interior portion of the shell is rounded and the ventral margin is somewhat rounded to almost straight, converging with the posterior-dorsal surface in a rounded point. The posterior ridge is somewhat full and rounded with the surface marked by irregular growth lines. The periostracum is somewhat glossy, olive-green, yellowish-brown or blackish, covered with many narrow, wavy, dark-green or blackish rays which are numerous towards the posterior margin. The glochidia are rather large, subovate and hookless. Hookless glochidia typically have a more spoon-shaped delicate shell adn are msot frequently on gill filaments of fish.

Taxonomy

Taxonomy of the genus Villosa is uncertain. Villosa trabalis and Villosa perpurpurea are very similar. Both are regarded as good species by the American Fisheries Society list (Turgeon et al, 1998). Simpson (1914) and Ortmann (1915) considered Villosa perpurpurea and Villosa trabalis to represent distinct species. However, Ortmann (1918) expressed doubts concerning their separation and later considered them to be varieties of the same species ("Micromya" trabalis in Ortmann, 1925). Recently, Hoggarth (1988) demonstrated that the glochidia of V. perpurpurea and V. trabalis are shaped differently, indicating that the two taxa are separate species. Revision of the genus Villosa may indicate that neither of these two species are actually members of that genus.

Historical Range

Historically, this species occurred in the upper portions of the Tennessee and Cumberland Rivers.

Current Range

The Cumberland bean is known only from the tributary streams of the upper Cumberland River in Kentucky and Tennessee.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Larvae: Larval mussels (i.e., glochidia) require a host.

Juvenile: For their first several months, juvenile mussels employ foot (pedal) feeding and are thus suspension feeders that feed on algae and detritus. Mussels tend to grow relatively rapidly for the first few years, and then slow appreciably at sexual maturity when energy is being diverted from growth to reproductive activities.

Adult: Adult freshwater mussels are filter-feeders, siphoning algae, bacteria, detritus, microscopic animals, and dissolved organic matter (Fuller 1974, pp. 221-222, Silverman et al. 1997, p. 1862; Nichols and Garling 2000, p. 874-876; Christian et al. 2004, p. 109).

Reproduction Narrative

Adult: The life history for Villosa trabalis is probably similar to that of most unionids. Males produce sperm are discharged into the surrounding water and dispersed by water currents. Females downstream from the males obtain these sperm during the normal process of siphoning water during feeding and respiration. The fertilized eggs retained in the posterior section of outer gills which are modified as brood pouches. Villosa trabalis is reported to be a bradytictic species (long-term brooder)(Bogan and Parmalee 1983). They breed from mid-summer to early-winter. Embryos develop in the female during the winter and are released the following spring or summer. This species is most often found associated with clean, fast-flowing water in stable substrate, which contains relatively firm rubble, gravel, and sand swept-free from siltation. Typically, the Cumberland Bean is found buried in shallow riffle and shoal areas and is often located under large rocks that must be removed by hand to inspect the habitat underneath. The Banded Sculpin (Cottus carolinae), Striped Darter (Etheostoma virgatum), Fantail Darter (E. flabellare), Greenside Darter (E. blennioides) and Redline Darter (E. rufilineatum) can all serve as hosts for this species (Guyot 2005). There is concern that the number of host fishes may not be adequate in the Big South Fork and Buck Creek to promote successful recruitment. Recent fish community surveys demonstrate significant recovery of the fish community as compared to historical conditions. Of the documented hosts listed by Guyot (2005), only Greenside Darter occurs in the mainstem of the Big South Fork Cumberland River. However, the Tuxedo Darter, E. lemniscatum, may be a surrogate host from the subgenus Catonotus for E. flabellare or E. virgatum; the Bloodfin Darter (Notonotus sangifluus), Bluebreast Darter (Nothonotus camurus), and/or Tippecanoe Darter (Nothonotus tippecanoe) may be a surrogate for N. ruflineatus. (USFWS, 2020)

Geographic or Habitat Restraints or Barriers

Larvae: Impoundments

Juvenile: Impoundments

Adult: Impoundments

Spatial Arrangements of the Population

Larvae: Clumped according to suitable resources

Juvenile: Clumped according to suitable resources

Adult: Clumped according to suitable resources

Environmental Specificity

Larvae: Specialist; requires a host

Juvenile: Generalist

Adult: Generalist

Tolerance Ranges/Thresholds

Larvae: likely low; sensitive to water quality impairments

Juvenile: likely low; sensitive to water quality impairments

Adult: likely low; sensitive to water quality impairments

Site Fidelity

Larvae: unknown

Juvenile: high

Adult: high

Dependency on Other Individuals or Species for Habitat

Larvae: host

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Adult: This species is most often found associated with clean, fastflowing water in stable substrate, which contains relatively firm rubble, gravel, and sand swept-free from siltation. Typically, V. trabalis is found buried in shallow riffle and shoal areas, often located under large rocks that must be removed by hand to inspect the habitat underneath. Ideal habitat conditions are difficult to find; much of the historical habitat for the species has likely been degraded and may be incapable of currently harboring the species.

Dispersal/Migration

Motility/Mobility

Larvae: Yes

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Larvae: non-migratory

Juvenile: non-migratory

Adult: non-migratory

Dispersal

Larvae: yes

Juvenile: low

Adult: low

Dependency on Other Individuals or Species for Dispersal

Larvae: dependent on host

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Larvae: Larval mussel movement and dispersal is dependent on their host's movement patterns.

Adult: Throughout the rest of their life cycle, mussels generally remain within the same small area where they released from the host fish. Juvenile and adult mussels may experience significant passive movement via strong water currents.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Populations of this species remain in small segments of Buck Creek, Big South Fork Cumberland River, and the Rockcastle River system, including Sinking Creek. The best population of this species is in the mainstem of the Rockcastle River (i.e., about a 40 mile reach), including lower Sinking Creek, but the species only occurs at sporadic locations. All streams show limited evidence of reproduction and recruitment. In populations in Buck Creek and Big South Fork Cumberland River, recruitment is likely very low and may be undetectable by standard survey techniques, if recruitment is occurring at all. In Buck Creek, the species is observed in about a four-mile reach and in the Big South Fork Cumberland River in only a few shoals. (USFWS, 2020)

Threats and Stressors

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: Possibly the single greatest factor which has contributed to the species' decline, as well as other members of the Cumberlandian faunal group, is the alteration and destruction of stream habitat due to the impoundment of the Tennessee and Cumberland Rivers and their headwater tributary streams for flood control, navigation, hydroelectric power production, and recreation. Since the early 1930s and 1940s, the Tennessee Valley Authority (TVA), Aluminum Company of America (Alcoa), and the Army Corps of Engineers have constructed numerous dams on the Tennessee and Cumberland River Systems. Stream impoundment affects species composition by eliminating those species not capable of adapting to reduced flows, altered temperatures, and anoxic conditions. Tributary dams typcailly have hypolimnial discharges that cause the stream below the dam to differ significantly from both preimpoundment conditions and from upstream river reaches. Hypolimnial discharges include altered temperature regimes, extreme water level fluctuations, reduced turbidity, seasonal oxygen deficits, and high concetnrations of certain heavy metals.

Stressor: Siltation
Exposure:
Response:
Consequence:
Narrative: Siltation is another factor which has severly affected freshwater mussels, especially Cumberlandian species. In rivers and streams, the greatest diversity and abundance of mussels is usually associated with gravel and/or sand substrates. These substrates are most ccommon in running water. Increases silt transport in our waterways due to strip mining, coal washing, dredging, farming, logging, and road construction are some of the more obvious results of human alteration of the landscape. Hynes (1974) states that there are two major effects of inorganic sediments introduced into the aquatic environment. The first is an increase in the turbidity of the water with a consequent reduction in the depth of light penetration and the second is a blanketing effect on the substrate. High turbidity levels due to the presence of suspended solids in the water column have a mechanical or abrasive action which can irritate, damage, or cause clogging of the gills or feeding structures of mollusks (Loar et al. 1980). Additionally, high levels of suspended solids may reduce or inhibit feeding by filter feeding organisms, such as mussels causing nutritional stress and mortality (Loosanoff 1961). Freshwater mussels are long-lived and sedentary by nature, many species have been unable to survive in a layer of silt greater than 0.6 cm (Ellis 1936). Fuller reported that siltation associated with poor agricultural practices and

deforestation of much of North America was probably the most significant factor impacting mussel communities. Mussel life-cycles can be affected indirectly from siltation by impacting host-fish populations by smothering fish eggs or larvae, reducing food availability, or filling interstitial spaces in gravel and rubble substrate, thus eliminating spawning beds and habitat critical to the survival of young fishes (Loar et al. 1980).

Stressor: Strip mining
Exposure:
Response:
Consequence:
Narrative: Coal production in the Appalachian region, which includes the headwater streams to the Cumberland and Tennessee Rivers, has increased dramatically in the last few decades. Branson (1974) stated that the future of the entire upper Kentucky River Basin as well as that of the Cumberland River looks very bleak because mining operations are being intensified to meet the growing demand for coal. This will result in increased silt run off and escalate impacts to the freshwater mussel fauna, especially the headwater tributary streams to the Cumberland River and the Powell and Clinch Rivers of hte Tennessee River System.

Stressor: Pollution
Exposure:
Response:
Consequence:
Narrative: An increasing number of streams throughout the US receive municipal, agricultural, and industrial waste discharges. The damaged suffered varies according to a complex of interrelated factors, which include the characteristics of the receiving stream and the nature, magnitude, and frequency of the stresses being applied.

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. A viable population of Villosa trabalis exists in Buck Creek, Rockcastle, and the Little South Fork Cumberland Rivers. These three populations are dispersed throughout each river so that it is unlikely that one event would cause the total loss of either population.

2. Through reestablishment and/or discoveries of new populations, viable populations exist in two additional rivers (to include at least one in the Tennessee River system). Each of these rivers will contain a viable population that is distributed such that a single event would be unlikely to eliminate Villosa trabalis from the river system.

3. The species and its habitat are protected from present and foreseeable human related and natural threats that may interfere with the survival of any of the populations.

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the upper Cumberland and Tennessee drainages and no foreseeable increase in coal-related siltation exists in streams containing Villosa trabalis.

Recovery Actions:

- 1. Augment and expand extant populations through propagation of juveniles.
- 2. Determine status and viability of known populations in Sinking Creek, Hiwassee River, Big South Fork of the Cumberland River, Little Chucky Creek, Rockcastle River, and Buck Creek.
- 3. Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality conditions, including the upper Clinch River in Tennessee and the Nolichucky, Paint Rock and Elk in Alabama.
- 4. Determine the degree of threat (e.g., coal mining, oil and gas drilling and water withdrawals, etc.) to each stream in which this species occurs. This could include assessments and/or a threats analysis using GIS.
- 5. Determine the genetic status of this species and V. perpurpurea, which appears to be a sister taxon to V. trabalis.
- 6. Conduct surveys on Rockcastle River, Barren Fork, Rocky River, and Falling Water River (tributaries to Caney Fork), West Harpeth and Jones Creek (tributaries to the Harpeth River in Tennessee), North and South Prongs Clear Fork and Brimstone Creek (tributaries to the Big South Fork Cumberland River), Obey River (West and East Forks) and Spring Creek (tributaries to the Cumberland River), and in the lower Hiwassee River downstream of the TVA Powerhouse in the Tennessee River system.
- 7. Evaluate TVA's minimum flow of 25 cubic feet per second downstream of the Hiwassee River to determine it the best appropriate flow regime to benefit V. trabalis.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Based on our review of the Cumberland bean, we believe the following measures are appropriate: • Revising the listing information, through the public rulemaking process, for the Cumberland Bean and Purple Bean to reflect the current understanding of the taxonomy of these species. • Augment and expand extant populations through propagation of juveniles. • Determine status and viability of known populations in Buck Creek, Rockcastle River, Sinking Creek, and Big South Fork of the Cumberland River. • Reestablish viable populations in other streams within the historical range that have suitable habitat and water quality conditions. • Determine the degree of threat (e.g., coal mining, oil and gas drilling and water withdrawals, etc.) to each stream in which this species occurs. This could include assessments and/or a threats analysis using GIS. • Conduct more surveys in selected streams in the Cumberland River system to determine if additional populations exist. • Conduct a Species Status Assessment and revise the Recovery Plan so that it incorporates the best available information on the Cumberland Bean. • Conduct a population viability assessment to estimate the likelihood of the species population dynamics, and also conduct a risk assessment to understand the uncertainty and provide guidance for conservation management. • Develop a protocol to evaluate release sites and determine the population size of cultured Cumberland Bean mussels for the reintroduction and restoration efforts (e.g., utilize pit tags to locate previously introduced individuals) (USFWS, 2020)

References

Five year review

final listing rule

recovery plan

Nature Serve

Nature Serve. USFWS. 2020. Cumberland Bean Villosa trabalis 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Kentucky Ecological Services Field Office Frankfort, Kentucky. 29 pp.

Nature Serve. USFWS. 2020. Cumberland Bean Villosa trabalis 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Kentucky Ecological Services Field Office Frankfort, Kentucky. 29 pp.

Recovery plan

five year review

USFWS. 2020. Cumberland Bean Villosa trabalis 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Kentucky Ecological Services Field Office Frankfort, Kentucky. 29 pp.