Appendix C: Animals

Snails

SPECIES ACCOUNT: *Achatinella spp.* (Oahu tree snails (41 species))

Species Taxonomic and Listing Information

Listing Status: Endangered Genus; 02/12/1981; Pacific Region (R1) (USFWS, 2016)

Physical Description

O`ahu tree snails are diverse in patterns, colors, and shapes but all average about 3/4 inch in length. Most have smooth, glossy, and oblong or ovate shells with a variety of colors, including yellow, orange, red, brown, green, gray, black, and white (USFWS, 2016).

Taxonomy

All 41 species of the genus Achatinella, also known as the O`ahu tree snails, are federally listed as endangered (USFWS, 2016). The Achatinella genus is comprised of (A.) abbreviata, apexfulva, bellula, buddii, bulimoides, byronii, caesia, casta, cestus, concavospira, curta, decipiens, decora, dimorpha, elegans, fulgens, fuscobasis, juddii, juncea, lehuiensis, leucorraphe, lila, livida, lorata, mustelina, papyracea, phaeozona, pulcherrima, pupukanioe, rosea, sowerbyana, spaldingi, stewartii, swiftii, taeniolata, thaanumi, turgida, valida, viridans, vittata, vulpina (USFWS, 2011). There are three recognized subgenera within the genus Achatinella: Bulimella, Achatinellastrum, Achatinella sensu strictu (USFWS, 1992).

Historical Range

The historical locations of each species are as follows: A. abbreviata: southern Ko`olau Mountains, on the leeward slopes; A. apexfulva: leeward slopes of the northern Ko`olau Mountains; A. bellula: leeward slopes of the southern Ko`olau Mountains; A. buddii leeward slopes of the southern Ko`olau Mountains; A. bulimoides: windward and leeward slopes of the northern Ko`olau Mountains; A. byronii: leeward slopes of the central Ko`olau Mountains; A. caesia: northern Ko`olau Mountains and on the windward slopes of the central Ko`olau Mountains (USFWS 1992); A. casta: leeward slopes of the central Ko`olau Mountains; A. cestus: leeward slopes of the southern Ko`olau Mountains; A. concavospira: southern Wai`anae Mountains; A. curta: northern portion of the Ko`olau Mountain range, most of its range was on the leeward slopes (USFWS 1992); A. decipiens: northern Ko`olau Mountains; A. decora: northern portion of the Ko`olau Mountain Range, most of its range was on the leeward slopes (USFWS 1992); A. dimorpha: northern half of the Ko`olau Mountains with most of its range on the windward slopes (USFWS 1992); A. elegans: windward slopes of the northern Ko`olau Mountains (USFWS 1992); A. fulgens: southern portion of the Ko`olau Mountain range, most of its range was on the leeward slopes; A. fuscobasis: southern portion of the Ko`olau Mountain range, most of its range was on the leeward slopes; A. juddii: leeward slopes of the central Ko`olau Mountains; A. juncea: leeward slopes of the northern Ko`olau Mountains; A. lehuiensis: southern Wai`anae Mountains (USFWS 1992); A. leucorraphe: leeward slopes of the central Ko`olau Mountains; A. lila: leeward slopes of the northern Ko`olau Mountains; A. livida: leeward slopes of the northern Ko`olau Mountains; A. lorata: leeward slopes of the southern Ko`olau Mountains (USFWS 1992); A. mustelina: Wai`anae Mountain range, spanning from the northern end to the southern end of the range; A. phaeozona: windward slopes of the southern Ko`olau Mountains, with a small portion of its historical range on the leeward side; A. papyracea: leeward slopes of the central Ko`olau Mountains (USFWS 1992); A. pulcherrima: windward slopes of the southern Ko`olau Mountains, with a small portion of its historical range on the leeward side; A. pupukanioe: windward slopes of the southern Ko`olau Mountains, with a small portion of its historical range on the leeward side; A. rosea: leeward slopes of the northern Ko`olau Mountains, with a small portion of its historical range on the leeward side; A. sowerbyana: windward and leeward slopes of the northern Ko`olau Mountains; A. spaldingi: central Wai`anae Mountains (USFWS 1992); A. stewartii: leeward slopes of the southern Ko`olau Mountains; A. swiftii: leeward slopes of the central Ko`olau Mountains; A. taeniolata: leeward slopes of the southern Ko`olau Mountains, with a small portion of its historical range on the leeward side; A. thaanumi: central Wai`anae Mountains (USFWS 1992); A. turgida: leeward slopes of the central Ko`olau Mountains; A. valida: leeward slopes of the northern Ko`olau Mountains, with a small portion of its historical range on the leeward side; A. viridans: leeward slopes of the southern Ko`olau Mountains (USFWS 1992); A. vittata: leeward slopes of the southern Ko`olau Mountains (USFWS 1992); A. vulpina: leeward slopes of the southern Ko`olau Mountains (USFWS 1992) (USFWS, 2011).

Current Range

Members of the genus Achatinella are currently found on the island of O’ahu, Hawai’i. Where once the snails were common in most of the native forests of the Ko’olau and Wai’anae Ranges of O’ahu, today they are restricted to remnant native forests on the high ridges of both ranges (USFWS, 1992). The most recent sighting of A. abbreviata was in 2008 near the summit of Waialae Nui, on the leeward side of the southern Ko`olau Mountains (N. Yuen, Biological Consultant, pers. comm. 2009). In 1998, one population of A. apexfulva was identified on the Paomaho Trail, in the Ko`olau Mountains on the island of O`ahu. A. bulimoides is found at only one location on the windward cliffs of Punalu`u, below the Ko`olau Summit Trail and north of the Poamoho Trail summit (US Army 2009). A. byronii is found in the northern Ko`olau Mountains. A. concavospira is found at ten locations in the southern Wai`anae Mountains. A. decipiens is found in the northern Ko`olau Mountains. A. fulgens is known to exist in the southern Ko`olau Mountains; it was found in Pia Valley in 2008. Most recently, two live A. fuscobasis were sighted in August 2008 in the upper reaches of Pia Valley (N. Yuen, Biological Consultant, pers. comm. 2011a). There are additional reports that a couple small populations of A. fuscobasis exist in the southern Ko`olau Mountains. A. lila is found at seven locations in the northern Ko`olau Mountains. A. livida is found in the northern Ko`olau Mountains, along the summit, where there is a continuous band of suitable habitat provided by native vegetation and high precipitation. Populations of A. mustelina are broadly distributed from the northern to southern ends of the Wai`anae Mountains, a distance of about 24 km. The most recent sighting of A. pulcherrima was in 1993, at the Opaeula drainage near the south fork of Opaeula Stream and on the Peahinaia Trail (USFWS 2003; OIP 2008). A. sowerbyana is found in the northern Ko`olau Mountains, where there is a continuous band of suitable habitat provided by native vegetation and high precipitation (USFWS, 2011).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Both adults and larvae graze on fungus on surface of leaves at night. During the day snails seal themselves to leaves and trunks, at night they move about to graze (NatureServe, 2015).

Reproduction Narrative

Adult: Hermaphroditic, but assumed to be self-sterile. Single embryo in uterus, embryos present at all times of the year. Young are born live at relatively large size. This species probably has low growth and reproductive rates (NatureServe, 2015). A study of two populations (Pahole and Palikea) of Achatinella mustelina, conducted by Hadfield et al. (1993) revealed new information on the species' biology and life history. The range of ages of adults when they first reproduce is three to five years (Hadfield et al. 1993) (USFWS, 2011). Hadfield and colleagues estimated the lifespan of A. mustelina to be at least 11 years. The number of young produced by an adult snail is estimated at 1 to 4 per year (USFWS, 1992).

Geographic or Habitat Restraints or Barriers

Adult: Occurs > 400 m elevation (NatureServe, 2015); A. byronii: 1,800 - 2,520 ft. elevation; A. concavospira: 2,140 - 2,600 ft. elevation; A. decipiens: 1,800 - 2,520 ft. elevation; A. lila: 2,300 - 2,760 ft. elevation; A. livida: 2,300 - 2,560 ft. elevation; A. mustelina: 1,550 - 3,780 ft. elevation; A. sowerbyana: 1,950 - 2,800 ft. elevation (USFWS, 2011)

Habitat Narrative

Adult: Inhabits native forest; little known about habitat requirements. Currently found in mountainous dry to wet forests and shrubland above 400 meters. Also observed on non-native plants. Young occupies same habitat as adults (NatureServe, 2015). All species of Achatinella live in trees and bushes (USFWS, 1992). Elevation ranges are available for the following species: A. byronii: 1800 ft. to 2520 ft. (549 m to 768 m); A. concavospira: 2140 ft. to 2600 ft. (652 m to 792 m); A. decipiens: 1800 ft. to 2520 ft. (549 m to 768 m); A. lila: 2300 ft. to 2760 ft. (701 m to 841 m); A. livida: 2300 ft. to 2560 ft. (701 m to 780 m) (US Army 2009); A. mustelina: 1550 ft. and 3780 ft. (472 m to 1152 m); A. sowerbyana: 1950 ft. to 2800 ft. (594 m to 853 m). The habitat of A. concavospira in the southern Wai`anae Mountains is characterized as varying between dry-mesic forest and wet mesic forest (US Army 2009). Populations of A. mustelina inhabiting dense and continuous forests have a higher percent survivorship than snail populations inhabiting isolated trees or open forests (Hadfield et al. 1993) (USFWS, 2011).

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)

Dispersal/Migration Narrative

Adult: Dispersal patterns not well known but believed to be restricted to relatively small areas perhaps single tree. Movement between trees is limited (NatureServe, 2015). Passive snail dispersal is caused by wind and increased by high wind gusts and increased humidity levels (Hall and Hadfield 2009) (USFWS, 2011).

Population Information and Trends

Population Trends:

Unknown (NatureServe, 2015); 16 species extinct (USFWS, 1992)

Species Trends:

Declining (USFWS, 2011)

Resiliency:

Very low (inferred from USFWS, 1992; see current range/distribution)

Redundancy:

A. mustelina: very high; A. sowerbyana: moderate; A. byronii, A. decipiens, A. lila, A. livida: low; A. fuscobasis: very low

Number of Populations:

A. bulimoides: 1; A. byronii: 9; A. decipiens: 9; A. fuscobasis: 1 - 2; A. lila: 4 - 6; A. livida: 4; A. mustelina: 98; A. sowerbyana: 18 (USFWS, 2011)

Population Size:

A. abbreviata: 1; A. apexfulva: 1 wild, 2 captive; A. bulimoides: 5 wild, 39 captive; A. byronii: 8; A. concavispira: 47; A. decipiens: 8 wild, 18 captive; A. fulgens: 14 wild, 15 captive; A. fuscobasis: 14 wild, 300 captive; A. lila: 22 wild, 586 captive; A. livida: 103 wild, 62 captive; A. mustelina: 114 captive; A. sowerbyana: 21 wild, 19 captive (USFWS, 2011)

Population Narrative:

The long term population trend is unknown (NatureServe, 2015). Sixteen species are now extinct, 5 species have not been seen in over 15 years, and 18 of the remaining 20 species are on the verge of extinction. Only A. mustelina and perhaps A. sowerbyana exist in substantial numbers today, but their ranges are greatly reduced, and recent observations show their numbers to be rapidly declining (USFWS, 1992). A. mustelina is the most abundant of the living species in the genus. Six Evolutionarily Significant Units for A. mustelina have been recognized, and each warrants individual management because they are evolving independent of one another. There are 98 populations of A. mustelina (US Army 2009b) and 114 individuals in captive propagation (Hadfield 2010). The most recent sighting of A. abbreviata was in 2008 (one individual). The population of A. apexfulva is not robust with only one wild individual observed in the past 6 years and only two individuals in captive propagation (Hadfield 2010). A. buddi individuals have not been observed in the past 10 years. There single known population of A. bulimoides, with 2 - 5 individuals found from 2004 - 2007. There were 39 captive A. bulimoides individuals in 2009. Eight A. byronii individuals were found in the wild in 2009 (US Army 2009). Nine of the sites for A. byronii are at least 100 m from each other and, therefore, are considered distinct populations. The most recent sightings of live A. concavospira were in October 2008; a total of 47 snails (17 large, 19 medium, and 11 small) were sighted on areas monitored by the Army Natural Resource Staff (ANRS). The most recent sighting of A. decipiens was in May 2009; eight live snails were found. There are 18 A. decipiens individuals in captive propagation (Hadfield 2010). Nine of the sites for A. decipiens are at least 100 m from other sites and, therefore, are considered distinct populations. Only 15 individuals comprise the captive population of A. fulgens (Hadfield 2010). In 2008, only 14 live A. fulgens snails were seen in the wild. The most recent field sighting of A. fuscobasis was in 2008; 14 live snails were found at two locations in Pia Valley. There are 300 A. fuscobasis individuals in the captive population

(Hadfield 2010). The most recent sighting of live A. lila in the field was in 2009; a total of 22 snails were observed (US Army 2009). There are 586 A. lila individuals in captive propagation (Hadfield 2010). More than half of the sites for A. lila are located at least 100 m from each other and, therefore, are considered distinct populations (US Army 2009). The most recent sightings of live A. livida in the field were in 2009; a total of 103 snails (63 large, 20 medium, and 20 small) was sighted across all four populations (US Army 2009). There are 62 A. livida individuals in captive propagation (Hadfield 2010). A. pulcherrima was last observed in 1993 (USFWS 1992). The most recent sightings of A. sowerbyana in the field were in April 2009; a total of 21 snails were seen (US Army 2009). Approximately 18 of the population-reference sites for A. sowerbyana are at least 100 m from each other and, therefore, are considered distinct populations. There are 19 A. sowerbyana individuals in captive propagation (Hadfield 2010). Based on the [FY2010 Recovery Data Call (August 2010), the status of all A. species is declining (USFWS, 2011). The following species have not been observed in recent times: the population of A. bellula was last observed in 1981; A. caesia has not been observed since 1990; A. casta was presumed likely extinct in 1992; A. cestus was last observed in 1966; A. curta was last observed 1989; A. decora was last observed in approximately 1900; A. dimorpha has not been seen since 1967; A. elegans has not been seen since 1952; A. juddii was last observed in 1958; there are no records of A. juncea being observed alive in the wild; A. lehuiensis was last observed in 1922; A. leucorraphe was last observed in 1989; A. lorata was last observed in 1979; A. papyracea was last observed prior to 1945; A. phaeozona was last observed in 1974; A. pupukanioe was last observed in 1980; A. rosea was last observed in 1949; A. spaldingi was last observed 1938; A. stewarti was last observed in the wild in 1963; in 2002, a tentative identification was made on a live snail and a shell observed in the wild to be A. stewartii but could have been A. bellula (M. Hadfield, pers. comm. 2011); A. swiftii was last observed in the 1970's; A. taeniolata was last observed in 1966; A. thaanumi was last observed in 1900; A. turgida was last observed in 1974; A. valida was last observed in 1951; A. viridans was last observed in 1979; A. vittata was last observed in 1953; A. vulpina was last observed in 1965 (USFWS 1992; 2011).

Threats and Stressors

Stressor: Habitat degradation (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Habitat degradation is a major threat to Achatinella spp.; however, the degree of habitat degradation varies within the historical range of each species. The tree-snail habitat within the historical range of Achatinella spp. continues to be threatened by the spreading of invasive plants into higher elevations and feral pigs (Sus scrofa) and goats (Capra hircus), hunting, and hiking. Tree-snail host plants are threatened by invasions from Psidium cattleianum (strawberry guava), Grevillea robusta (silk oak), Schinus terebinthifolius (christmas berry), Lantana camara, Clidemia hirta (USFWS 1992), Leucaena leucocephala (koa haole), and Miconia calvescens (Weed Risk Assessments for Hawai`i and Pacific Islands 2011). Invasive plant species compete with host plant species for space and resources. Feral ungulates trample host plant species and spread the seeds of invasive plant species (USFWS 1992) (USFWS, 2011).

Stressor: Predation (USFWS, 2011)
Exposure:
Response:

Consequence:
Narrative: Achatinella spp. are threatened by predation from the rosy wolf snail (Euglandina rosea) and rats (Rattus exulans, Rattus rattus, and Rattus norvegicus) (USFWS 1992; Hadfield et al. 1993; Hadfield and Saufler 2009). E. rosea preys on all sizes of snails. Predation by E. rosea can result in the extirpation of a snail population in less than one year. When E. rosea preys on snails, the shell is left clean and undamaged. Rats prey on larger snails. When rats prey on snails, the shells are crushed (Hadfield et al. 1993). The Jackson's chameleon (Chamaeleo jacksonii) has recently been documented as a predator of Achatinella spp. and may pose a major threat to their existence. Jackson's chameleons are found in the Ko`olau and Wai`anae Mountains (Holland et al. 2009); however, their impact on Achatinella spp. is not well documented. The terrestrial snail Gonaxis kibweziensis was introduced around O`ahu to control Achatina fulica or African Snail. Gonaxis kibweziensis have been observed preying on Achatina egg clutches and juvenile under the length of 35mm and unidentified native terrestrial snails (Davis and Butler 1964). Carnivorous snails introduced to control other introduced snails pose a significant threat to Achatinella spp. Although released at various elevations around O`ahu (Davis and Butler 1964), they are mainly found in the lowland (B. Holland, University of Hawai`i, pers. comm. 2011a). In April 2011, this species was found in the back of Kuliouou Valley on O`ahu at 2,200 feet elevation (N. Yuen, Biological Consultant, pers. comm. 2011b; Hawaiianforest.com 2011). The terrestrial snail Oxychilus alliarius, and the terrestrial flatworm Geoplana septemlineata, which reportedly eats snails (USFWS 1992) may threaten Achatinella spp.; however, predation on Achatinella spp. by G. septemlineata and O. alliarius has not been observed (USFWS 1992). Additionally, the flatworm Platydemis manokwari is a known predator of land and arboreal snails on many Pacific islands (Hopper and Smith 1992; Sugiura 2009). Platydemis manokwari is known to occur on O`ahu from low elevations up to Mount Ka`ala in the Wai`anae Mountains (US Army 2008) and in the Ko`olau Mountains (B. Holland, University of Hawai`i, pers. comm. 2011b) (USFWS, 2011).

Stressor: Stochastic events (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Species that are endemic to small portions of a single island are inherently more vulnerable to extinction than widespread species because of the higher risks posed to a few populations and individuals by random demographic fluctuations; localized catastrophes such as hurricanes, landslides, flooding, and disease outbreaks; and climate change effects such as lowland predators moving to higher elevations (USFWS, 2011).

Stressor: Climate change (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Climate change may also pose a threat to Achatinella species. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to these species (USFWS, 2011).

Stressor: Military activities (USFWS, 2011)
Exposure:
Response:
Consequence:

Narrative: Tree-snail species are threatened directly and indirectly by training activities. Food disposed of during military troop activities leads to an increase in the size of rat populations. Seeds of non-native plants may be spread along the trails used by the Military via transportation on boots, vehicles, equipment, or clothing. Dismounted troop movement in forested areas may result in the trampling of host plants and possibly tree snails. Discarded cigarettes, military vehicles and other equipment used during training activities can be potential sources of fire ignition (USFWS 2003). The majority of the historical range of A. apexfulva lies within the US Army's Kawailoa Training Area and Schofield Barracks East Range, (USFWS 1992; USFWS 2003). Portions of the historical range of A. bulimoides lie within the US Army's Kahuku Training Area, Kawailoa Training Area, and Schofield Barracks East Range (USFWS 1992; USFWS 2003). The portion of the historical range of A. byronii lies within the US Army's Kawailoa Training Area and Schofield Barracks East Range (USFWS 1992; USFWS 2003). The northern tip of the historical range of A. concavospira lies within the US Army's Schofield Barracks Military Reservation and South Range Acquisition Area (USFWS 1992; USFWS 2003). The majority of the historical range of A. curta lies within the US Army's Kawailoa Training Area (USFWS 1992; USFWS 2003). The southeastern edge of the historical range of A. decipiens lies within the US Army's Kawailoa Training Area and Schofield Barracks East Range (USFWS 1992; USFWS 2003). The majority of the historical range of A. decora lies within the US Army's Kawailoa Training Area. (USFWS 1992; USFWS 2003). The historical range of A. dimorpha overlaps portions of the US Army's Kahuku Training Area, Kawailoa Training Area, and Schofield Barracks East Range (USFWS 1992; USFWS 2003). The historical range of A. elegans overlaps the southern end of the US Army's Kahuku Training Area, Kawailoa Training Area (USFWS 1992; USFWS 2003). The majority of the historical range of A. juncea overlaps the southern half of the US Army's Kawailoa Training Area (USFWS 1992; USFWS 2003). The historical range of A. leucorraphe overlaps portions of the US Army's Kawailoa Training Area and Schofield Barracks East Range (USFWS 1992; USFWS 2003). The majority of one of the two historical ranges of A. lila lies within the US Army's Kawailoa Training Area (USFWS 1992; USFWS 2003). The majority of the historical range of A. livida lies within the US Army's Kawailoa Training Area (USFWS 1992; USFWS 2003). Portions of the northern historical range of A. mustelina lie within the US Army's Makua and Schofield Barracks Military Reservations (USFWS 1992; USFWS 2003). Portions of the historical range of A. papyracea lie within the US Army's Kawailoa Training Area and Schofield Barracks East Range (USFWS 1992; USFWS 2003). The majority of the historical range of A. pulcherrima lies within the US Army's Kawailoa Training Area and a small portion lies within the US Army's Schofield Barracks East Range (USFWS 1992; USFWS 2003). Large portions of the historical range of A. rosea lie within the US Army's Kawailoa Training Area and Schofield Barracks East Range (USFWS 1992; USFWS 2003). The majority of the historical range of A. sowerbyana lies within the US Army's Kahuku Training Area and Kawailoa Training Area (USFWS 1992; USFWS 2003). The majority of the historical range of A. spaldingi lies within the US Army's Kawailoa Training Area. (USFWS 1992; USFWS 2003). The majority of the historical range of A. swiftii lies within the US Army's Kawailoa Training Area (USFWS 1992; USFWS 2003). The majority of the historical range of A. thaanumi lies within the US Army's Kawailoa Training Area (USFWS 1992; USFWS 2003). The historical range of A. valida lies within portions of the US Army's Kahuku and Kawailoa Training Areas (USFWS 1992; USFWS 2003) (USFWS, 2011).

Stressor: Collection (USFWS, 2011)
Exposure:
Response:
Consequence:

Narrative: Illegal shell collecting is a continuing threat to Achatinella spp. (USFWS, 2011).

Recovery

Reclassification Criteria:
No downlisting or delisting goal can be set at this time. However, the O'ahu tree snails may be considered for down listing once all remaining populations have been located and stabilized (USFWS, 1992).

Delisting Criteria:
Not available

Recovery Actions:
- Initiate captive propagation by removing individuals from presently known populations (USFWS, 1992).
- Locate additional habitat/populations of Achatinella spp. within historic range and initiate captive propagation of same (USFWS, 1992).
- Secure essential habitat (USFWS, 1992).
- Assess and manage current threats to the continued existence of tree snails (USFWS, 1992).
- Conduct research on ecology of Achatinella spp. (USFWS, 1992).
- Begin reestablishment of snail colonies (USFWS, 1992).

Conservation Measures and Best Management Practices:
- Identify the actions to take when Achatinella spp. are found in the wild (USFWS, 2011).
- Routinely survey and monitor areas with existing populations of Achatinella spp. (USFWS, 2011).
- Survey areas with suitable habitat and within the historical range of Achatinella spp. (USFWS, 2011).
- Identify suitable habitat within the historical range of Achatinella spp. to construct predator proof exclosures where snails found in the wild could be moved into (USFWS, 2011).
- Survey and monitor the presence and abundance of Euglandina rosea, rats, Geoplana septemlineata, Platydemis manokwari, Oxychilus alliarius, and Jackson's Chameleons within the species' historical range (USFWS, 2011).
- Assess the impacts of Euglandina rosea, rats, Geoplana septemlineata, Platydemis manokwari, Oxychilus alliarius, and Jackson's Chameleons on Achatinella spp. (USFWS, 2011).
- Assess the impact of feral pigs and other ungulates on tree-snail habitat (USFWS, 2011).
- Collect anecdotal information on other potential predators of Achatinella spp. such as Gonaxis kibweziensis, skinks, and birds (USFWS, 2011).
- Design and implement more effective predator elimination techniques within the historical range of Achatinella spp. (USFWS, 2011).
- Control feral ungulates within the historic range of Achatinella spp. (USFWS, 2011).
- Remove invasive plant species responsible for habitat degradation (USFWS, 2011).
- Conservation measures for A. apexfulva include captive propagation and genetic research. Individuals of Achatinella apexfulva have been maintained in the Hawaiian Tree Snail Conservation Captive-Propagation Lab at the University of Hawai`i at Manoa since 1994. The population of A. apexfulva that has been monitored by the ANRS since 1998 is not managed to control predators; a predator-exclosure fence is not present and no rat-control efforts are underway (US Army 2009) (USFWS, 2011).

- Continue and possibly expand captive-propagation efforts with the intended goals of increasing the population size in a predator-free environment and eventually reintroducing captive-reared Achatinella spp. into the wild (USFWS, 2011).
- Develop reintroduction plans for future releases into predator free sites in the wild (USFWS, 2011).
- Identify suitable habitat sites that may serve as potential reintroduction sites for captive-reared Achatinella spp. (USFWS, 2011).
- Individuals of Achatinella bulimoides have been maintained in the captive-propagation lab at the University of Hawai`i at Manoa since 2005. The lab population of A. bulimoides has steadily increased, reaching 39 individuals as of December 2009 (M. Hadfield, University of Hawai`i, pers. comm. 2010) (USFWS, 2011).
- If additional A. bulimoides individuals or populations are found in the wild, its geographical position and area should be mapped (USFWS, 2011).
- Immediately implement the best available predator control measures if an individual(s) is found (USFWS, 2011).
- Continue and possibly expand captive-propagation efforts with the intended goals of increasing the population size in a predator-free environment and eventually reintroducing captive-reared Achatinella spp. into the wild (USFWS, 2011).
- Identify sites where Achatinella spp. are present that may be potential locations for predator exclosure fences (USFWS, 2011).
- Individuals of Achatinella decipiens have been maintained in the Hawaiian Tree Snail Conservation Captive-Propagation Lab at the University of Hawai`i at Manoa since 1990. Other conservation measures include a predator exclosure and weed and rat control (US Army 2009) (USFWS, 2011).
- Individuals of A. fulgens have been maintained in the captive-propagation facility at the University of Hawai`i at Manoa since 2006 when twenty live snails were collected (USFWS, 2011).
- Individuals of A. fuscobasis have been maintained in the captive-propagation lab at the University of Hawai`i at Manoa since 1991 (USFWS, 2011).
- Individuals of Achatinella lila have been maintained in the captive-propagation lab at the University of Hawai`i at Manoa since 1997 (USFWS, 2011).
- Individuals of Achatinella livida have been maintained in the captive-propagation lab at the University of Hawai`i at Manoa since 1997. One population has an ungulate fence, with weed and rat control being conducted (US Army 2009) (USFWS, 2011).
- Individuals of Achatinella mustelina have been maintained in the captive-propagation lab at the University of Hawai`i at Manoa since 1989. The Natural Area Reserve System, under the Hawaii Division of Forestry and Wildlife, constructed predator-exclosure fences around two populations of A. mustelina; the Kahanahaiki exclosure and the Pahole exclosure (USFWS, 2011).
- Individuals of A. sowerbyana have been maintained in the captive-propagation lab at the University of Hawai`i at Manoa since 1993 (USFWS, 2011).

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SPECIES ACCOUNT: *Anguispira picta* (Painted snake coiled forest snail)

Species Taxonomic and Listing Information

Listing Status: Threatened; August 2, 1978; Southeast region (R4)

Physical Description

Anguispira picta is a strongly depressed, dome-shaped snail with a sharp, perfectly smooth, white carina (Fig. 1a). Adults range from 17-21 mm in width and 9-10 mm in height, and have six whorls. (USFWS, 1982) (USFWS, 1982).

Taxonomy

This snail is similar to Anguispira cumberlandiana which occurs on the Cumberland Plateau almost all around Buck Creek Cove. In fact, Pilsbury (1948) considered it a subspecies of A. cumberlandiana. Further work by Solem (1976) confirmed its species status. A. picta can be distinguished from A. cumberlandiana by its carina, sculpture, color pattern and habitat. The other species of Anguispira are rounded or only slightly angular at the periphery: A. picta and some forms of A. cumberlandiana are acutely carinate (and strongly depressed). The carina in A. picta is white and smooth while in A. cumberlandiana it is often serrate. In A. picta the ribbing is weak and almost obsolete on the body whorl while in A. cumberlandiana it is quite strong. A. picta is much more colorfully marked than A. cumberlandiana and usually carries the indistinct flame-like markings on the bottom of the shell. A. picta prefers limestone crevices while A. cumberlandiana is known to live either on rocks or under logs (USFWS, 1982).

Historical Range

Historically, it was only known from Buck Creek Cove, Franklin Co., Tennessee (Hubricht, 1972); a much smaller range than what is known today (NatureServe, 2015).

Current Range

Withers (2003; 2004) found the species from a minimum of 5.3 miles and 4.5 miles of Cumberland Plateau escarpment on the west and east sides of Crow Creek Valley drainage, Tennessee (and expanding at least partially into Alabama) in two contiguous bands of occupied habitat for a total of eight population segments (NatureServe, 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: It seems to feed on lichens growing on rock faces (USFWS, 1982).

Reproduction Narrative

Adult: Unknown (USFWS, 1982)

Geographic or Habitat Restraints or Barriers

Adult: Frozen areas, waterbodies and dry areas (USFWS, 1982).

Spatial Arrangements of the Population

Adult: Clumped (inferred from NatureServe, 2015).

Environmental Specificity

Adult: Narrow/Specialist (inferred from NatureServe, 2015).

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015).

Site Fidelity

Adult: High (inferred from NatureServe, 2015).

Habitat Narrative

Adult: Associated with Monteagle limestone outcrops and cliff faces in the escarpment of the Cumberland Plateau (Withers, 2003) (NatureServe, 2015). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 1982; NatureServe, 2015). Barriers include barriers to dispersal such as the presence of permanent water bodies greater than 30 m in width, permanently frozen areas (e.g. mountaintop glaciers) which generally lack land snails (Frest and Johannes, 1995), or dry, xeric areas with less than six inches precipitation annually, as moisture is required for respiration and often hatching of eggs.

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: Unlikely (inferred from NatureServe, 2015).

Dispersal/Migration Narrative

Adult: Terrestrial gastropods do not move much usually only to find food or reproduce. Olfaction is the primary sensory behavior utilized to find and move toward a food item (on the scale of cm to m) although Atkinson (2003) found that Anguispira alternatawas capable of switching foraging behavior when snails encountered a physical barrier to movement. Fisher et al (1980) reported maximum movement rate of Rumina decollata (Linnaeus, 1758), an introduced pest species in California spreading relatively rapidly (for a snail), to be 20 m in three months (= 6.67 m/month) in an irrigated orchard. Tupen and Roth (2001) reported the movement rate for the same species in an un-irrigated native scrub on San Nicolas Island to be 0.4 km in 12 years (= 33.33 m/month). South (1965) found in dispersal studies of the slug, Deroceras reticulatum, that slugs traveled a mean distance of 1.13 m in seven days indicating this species disperses little throughout its life. Giokas and Mylonas (2004) found mean dispersal and minimal movement distances were very small (16.2 and 5.4 m, respectively) for Albinaria coerulea, with few individuals dispersing longer distances. Even the most extreme dispersal distances, such as 500 m for the giant African land snail Achatina fulica (Tomiyama and Nakane, 1993), do not approach the scale of km. Viable land snail populations generally occupy small areas. Frest and Johannes (1995) report the largest Oreohelix colony they observed was one mile (1.67 km) long and 0.25 miles (0.41 km) wide while the smallest was six feet (183 cm) long and two feet (61 cm) wide (NatureServe, 2015). Immagration/emigration is inferred based on the information given above.

Population Information and Trends

Population Trends:
Decreasing (NatureServe, 2015)

Resiliency:
Low (inferred from NatureServe, 2015).

Representation:
Low (inferred from NatureServe, 2015).

Redundancy:
Low (inferred from NatureServe, 2015).

Number of Populations:
6 to 20 (NatureServe, 2015)

Population Narrative:
NatureServe (2015) notes that the long term population trend is a decline of <30%. Resiliency, redundancy and representation are inferred based on known populations and habitat specificity.

Threats and Stressors

Stressor: Timber Harvest (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Due to the fact that A. picta occurs solely on private lands, on which timber harvesting is not subjected to coordination with state or Federal agencies in Tennessee, destruction or modification of habitat through timber harvest is unregulated (USFWS, 2008).

Stressor: Residential Development (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Residential development poses an indirect threat in the form of potential habitat modification. Residential development on the Cumberland Plateau, from which Crow Creek valley receives surface runoff, has increased in recent years (USFWS, 2008).

Stressor: Limestone quarrying (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: The potential threat of limestone quarrying exist throughout the range of A. picta and is imminent in one location. An active quarry is mining within the species habitat and is expected to result in destruction of habitat containing approximately 10% of the known locations and further fragmenting habitat unless section 7 consultation is required (USFWS, 2008).

Recovery

Reclassification Criteria:
Recovery Priority Number: 8

Delisting Criteria:
Protection from human-related threats (USFWS, 2008).

No evident natural threats (USFWS, 2008).

A population monitoring program must be established (USFWS, 2008).

Control of collection of the species (USFWS, 2008)

Recovery Actions:
- This criteria has not been met. The entire population occurs on private lands. Within these private lands, a project is underway to reopen a limestone quarry in the northern extent of the range. Development of this quarry will not only destroy a considerable amount of occupied habitat, it will fragment the northern extent of this species range from currently contiguous habitats extending along the southeast slope of Crow Creek valley, limiting dispersal potential between the two. This could prevent recolonization of suitable habitat should localized extinctions occur, disrupting metapopulation processes (USFWS, 2008).
- This has been met (USFWS, 2008).
- No monitoring program has been established for A. picta (USFWS, 2008).
- Collection of A. picta beyond what is allowed by the Tennessee Wildlife Resources Agency and USFWS is not though to pose a threat to this species (USFWS, 2008).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS: A. Protect habitat on the west side of Crow Creek Valley through either property acquisition by a government agency or conservation organization or by securing conservation easements or other binding agreements with private property owners. Pursue opportunities for developing conservation enhancement agreements, habitat conservation plans, or safe harbor agreements when appropriate. B. Develop and implement a monitoring program for A. picta that tracks fluctuations in patch occupancy in specific locations and incorporates measures of population abundance, density, and/or frequency of occurrence in those patches. C. Investigate the influence of microhabitat factors, including but not limited to soil moisture, relative humidity, limestone mineralogy, leaf litter, and canopy cover on the distribution of A. picta. D. Investigate life history, foraging behavior, and food preferences of A. picta. Recovery

efforts for this species are hindered by a lack of basic information on reproductive biology, demographics, dispersal ability, and food habits. E. Conduct an outreach and education campaign directed toward the residents of the town of Sherwood, Crow Creek Valley, and civic leaders in Franklin County. Such a program should familiarize the target audience with the knowledge that this endemic, federally protected species is dependent upon conservation of the forested ecosystem of the Cumberland Plateau escarpment in Crow Creek Valley (USFWS, 2016).

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SPECIES ACCOUNT: *Antrobia culveri* (Tumbling Creek cavesnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/14/2002; Great Lakes-Big Rivers Region (R3) (USFWS, 2016)

Physical Description

The Tumbling Creek cavesnail is a small (2 mm diameter, 2.4 mm height)with a small, conical, well- rounded, pale-yellow shell containing about 3.5 whorls (Hubricht 1971). (USFWS, 2001)

Historical Range

The Tumbling Creek cavesnail is not known to have occurred beyond Tumbling Creek. However, it was previously known from a 229 meter reach in 1974, but only in 14 meters of Tumbling Creek, including a small tributary, when emergency listed in 2001. (USFWS, 2001)

Current Range

The Tumbling Creek cavesnail is known only from in single stream in Tumbling Creek Cave in southwestern Missouri (Wu et. al. 1997). (NatureServe, 2015)

Critical Habitat Designated

Yes; 6/28/2011.

Legal Description

On June 28, 2011, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the Tumbling Creek cavesnail (Antrobia culveri) under the Endangered Species Act of 1973, as amended (Act). In total, approximately 25 acres (10.25 hectares) located in Taney County, Missouri, fall within the boundaries of the critical habitat designation.

Critical Habitat Designation

One unit, totaling approximately 25 ac (10.12 ha), is designated as critical habitat for the Tumbling Creek cavesnail.

Tumbling Creek, Taney County, Missouri. The unit includes the entire length of Tumbling Creek, from its emergence in Tumbling Creek Cave (southeast of the intersection of Routes 160 and 125) downstream to its confluence with Bear Cave Hollow and Owens Spring upstream of Big Creek, encompassing 25 ac (10.12 ha). This section of Tumbling Creek and the associated spring are under private ownership by Tom and Cathy Aley of the Ozark Underground Laboratory and contain all of the essential physical and biological features necessary for the Tumbling Creek cavesnail.

Primary Constituent Elements/Physical or Biological Features

The critical habitat unit is designated for Taney County, Missouri. Within this area, the primary constituent elements of the physical and biological features essential to the conservation of the Tumbling Creek cavesnail consist of five components:

(i) Geomorphically stable stream bottoms and banks (stable horizontal dimension and vertical profile) in order to: (A) Maintain bottom features (riffles, runs, and pools) and transition zones between bottom features; (B) Continue appropriate habitat to maintain essential riffles, runs, and pools; and (C) Promote connectivity between Tumbling Creek and its tributaries and associated springs to maintain gene flow throughout the population.

(ii) Instream flow regime with an average daily discharge between 0.07 and 150 cubic feet per second (cfs), inclusive of both surface runoff and groundwater sources (springs and seepages).

(iii) Water quality with temperature 55–62 °F (12.78–16.67 °C), dissolved oxygen 4.5 milligrams or greater per liter, and turbidity of an average monthly reading of no more than 200 Nephelometric Turbidity Units (NTU; units used to measure sediment discharge) for a duration not to exceed 4 hours.

(iv) Bottom substrates consisting of fine gravel with coarse gravel or cobble, or bedrock with sand and gravel, with low amounts of fine sand and sediments within the interstitial spaces of the substrates.

(v) Energy input from guano that originates mainly from gray bats (Myotis grisescens) that roost in the cave; guano is essential in the development of biofilm (the organic coating and bacterial layer that covers rocks in the cave stream) that cavesnails use for food.

Special Management Considerations or Protections

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 the effective date of this rule.

Various activities in or adjacent to the critical habitat unit described in the final rule may affect one or more of the primary constituent elements. Threats to the essential physical and biological features necessary for the Tumbling Creek cavesnail that may require special management and protection include: • Actions associated with the management of water levels of Bull Shoals Reservoir (such as increased sedimentation or bank erosion on the terminal portions of Tumbling Creek from backwater flooding); • Significant changes in the existing flow regime of Tumbling Creek, its tributaries. or associated springs; • Significant alteration of water quality; • Significant alteration in the quantity of groundwater and spring discharge sites; • Alterations to septic systems that could adversely affect the quality of Tumbling Creek; • Other watershed and floodplain disturbances that release sediments or nutrients into the water; • The accidental introduction of nonnative aquatic species into the stream due to backwater flooding of Bull Shoals Reservoir into Tumbling Creek; or • The potential effects of WNS on bats occupying the cave.

Life History

Feeding Narrative

Adult: Although little is known regarding the biology of this cavesnail, Greenlee (1974) postulated that the species feeds on aquatic microfauna (i.e., the microscopic, bacterial film or “biofilm" that is potentially ingested by the cavesnail). Because Tumbling Creek cavesnails have been concentrated in sections of Tumbling Creek Cave that are usually adjacent to large deposits of bat guano, it has been postulated that Antrobia culveri is indirectly dependent upon these deposits for food (Greenlee 1974). USFWS, 2003)

Reproduction Narrative

Adult: Little is known about its reproductive behavior beyond that there are both male and female individuals; there is no information on mating behavior. Although not yet documented, eggs are likely deposited in gelatinous egg masses (Aley and Ashley 2003). It is likely that rock and gravel substrates that are free from silt are important elements necessary for successful propagation, especially for attachment of gelatinous egg masses. (USFWS, 2011)

Environmental Specificity

Adult: Very narrow specialist (NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Greenlee (1974) reported that the species was found primarily on “3 inch gravel substrate”, with a few individuals observed using the recesses of a solid rock stream bottom. The species is usually observed on the undersurface of rocks and gravel of various sizes (Ashley unpub. data; McKenzie in litt., September 16, 1996; Ashley and McKenzie, pers. obs.). Although Greenlee (1974) stated that the Tumbling Creek cavesnail was absent from areas of the stream that contained bat guano, subsequent observers (Ashley 2001a; Ashley and McKenzie, pers. obs.) have noted it in portions of Tumbling Creek where bat guano occurs. Greenlee (1974) noted that the species appears to prefer areas of the stream that lack silt, but Ashley (2000) found no significant differences in snail populations between habitats having silt and those lacking silt. There is insufficient data to determine if silt is detrimental to the Tumbling Creek cavesnail. (USFWS, 2003) Nevertheless, siltation is considered a potential concern (USFWS, 2011)

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Life history aspects of this species, other than limited food information, are unknown. (USFWS, 2003)

Population Information and Trends

Population Trends:

Declining (USFWS, 2003)

Species Trends:

Declining (USFWS, 2003)

Resiliency:

Low (inferred from FWS, 2003)

Representation:

Low (inferred from FWS, 2003)

Redundancy:

Low (inferred from FWS, 2003)

Number of Populations:
1 (USFWS, 2003)

Population Size:
0-50 individuals (USFWS, 2003)

Population Narrative:
Greenlee (1974) estimated the population of Tumbling Creek cavesnails at 15,118 individuals. In 1995, monitoring stations were established and estimates within these stations fluctuated both seasonally and annually, and ranged from a high of 1,166 individuals on September 3, 1997, to a low of 0 individuals on 12 survey dates in 2001-2003. However, 17 individuals were found in one 2002 survey, and an additional individuals 40 individuals were found upstream of the sampling stations in 2001. While differing sampling methods made the results impossible to directly compare survey data by Greenlee (1974) with later surveys from 1997-2003, it appears that the numbers of Antrobia culveri have declined significantly; a decrease from 2.16 cavesnails per plot to 0.27 cavesnails per plot would represent an approximate 88 percent decrease in the species' density over the 22-year period between 1974 and 1995. (USFWS, 2003)

Threats and Stressors

Stressor: Siltation (USFWS, 2001)
Exposure:
Response:
Consequence:
Narrative: Increased silt loads within Tumbling Creek could adversely affect the cavesnail by hampering reproduction and recruitment by suffocating juvenile cavesnails (Ashley 2000). Clay particles within deposited silt have settled between gravel and rocks and cemented them together and to the stream bottom (Tom and Cathy Aley, pers. comm., August 2001). Such cementing decreases habitat available to cavesnails, because they are generally restricted to the undersurface of gravel and rocks. Interestingly, Ashley's (2000) results revealed that some older individuals use silt-covered substrates. This is different from the observations made by Greenlee (1974) who noted that cavesnails were not observed in areas of the stream where fine silt was deposited. Ashley's observations may be because of a reduction in the amount of silt-free substrates preferred by cavesnails which could force the species to use less favorable habitats. Although silt has been a component of Tumbling Creek since Greenlee's initial survey in 1974, it has apparently increased significantly since that date (Tom and Cathy Aley, pers. comm., August 2001). Additional research is needed to determine the degree of silt deposition within Tumbling Creek and if the deposition of silt into the cave is adversely impacting the species, especially smaller and younger individuals (Ashley 2000). (USFWS, 2001)

Stressor: Surface soil erosion (USFWS, 2001)
Exposure:
Response:
Consequence:
Narrative: Surface soil erosion has resulted from a variety of human activities. An earthen dam burst. Pastureland has been severely degraded and eroded due to overgrazing which has

removed nearly all vegetation within the riparian corridors of all semi-permanent and intermittent streams on one of the surface land parcels. Harvey (1980) identified ``timber cutting and land clearing for raising livestock, extending urban sprawl, and highway building'' as potential sources of ``accelerated erosion.'' In addition to these sources, the construction of fire lanes associated with controlled burning on Forest Service property within the recharge area may increase the threat of soil erosion with a resulting decrease in water quality in Tumbling Creek. (USFWS, 2001)

Stressor: Diminshed water quality (chemical) (USFWS, 2001)
Exposure:
Response:
Consequence:
Narrative: In addition to siltation, other factors within the recharge area of Tumbling Creek Cave could contribute to the deterioration of the water quality of Tumbling Creek and include: (1) increase in ammonia and nitrate loads from livestock feedlots that could lead to reductions in dissolved oxygen levels, (2) chemicals used for highway maintenance or from accidental spills, and (3) contaminants from different types of trash or hazardous waste materials deposited into sinkholes, ravines, and depressions. Whether these factors are occurring on the parts of the recharge area that are outside of the current ``conservation ownership'' remains to be determined. (USFWS, 2001)

Stressor: Water quantity (USFWS, 2001)
Exposure:
Response:
Consequence:
Narrative: As a result from the close hydrologic association of Tumbling Creek with nearby Bull Shoals Lake, occasional high water levels in this reservoir are believed to cause water to backup into the cave stream, threatening roosting bats and the cavesnail (Aley, pers. comm., July 16, 2000). The conservation pool of the reservoir may be increased by 10 feet, which will likely increase the frequency and duration of the backup events in Tumbling Creek Cave. Conversely, drought may also be a contributing factor to the decline of the cavesnail. Precipitation within the recharge area for Tumbling Creek Cave has been below normal for an extended period. Reduced flows in the cave stream, especially when combined with other threats, could hamper essential life history requirements (e.g., reproduction, food availability, water temperature); decrease the flushing of silt, guano, and harmful contaminants from the stream; and create an environment more favorable for competitors (e.g., limpets, isopods, and amphipods). (USFWS 2001)

Stressor: Small population size (USFWS, 2001)
Exposure:
Response:
Consequence:
Narrative: The small population size and endemism of Antrobia culveri makes it vulnerable to extinction due to genetic drift, inbreeding depression, and random or chance changes to the environment (Smith 1990) that can significantly impact cavesnail habitat. Inbreeding depression can result in death, decreased fertility, smaller body size, loss of vigor, reduced fitness, and various chromosome abnormalities (Smith 1990). Habitat loss and degradation increase a species' vulnerability to extinction (Noss and Cooperrider 1994). Current threats to the habitat of

the Tumbling Creek cavesnail may exacerbate potential problems associated with its low population numbers and increase the chances of this species going extinct. (USFWS, 2001)

Recovery

Reclassification Criteria:
1. The population is stable or increasing for 10 consecutive years with at least 1,500 individuals. (USFWS, 2003)

2. A minimum of 80% of the surface habitat within the recharge area of Tumbling Creek Cave, including a minimum of 75% of all riparian corridors, sinkholes and losing streams, is appropriately managed. (USFWS, 2003)

3. Water quality monitoring fails to detect levels of any water pollutant that exceeds USEPA recommended water quality or exceed known toxicity thresholds for the species for 10 consecutive years. (USFWS, 2003)

Delisting Criteria:
1. The population is stable or increasing for an additional 10 consecutive years with at least 5,000 individuals. (USFWS, 2003)

2. A minimum of 90% of the surface habitat within the recharge area of Tumbling Creek Cave, including a minimum of 85% of all riparian corridors, sinkholes and losing streams, is appropriately managed. (USFWS, 2003)

3. Water quality monitoring fails to detect levels of any water pollutant that exceeds USEPA recommended water quality or exceed known toxicity thresholds for the species for an additional 10 consecutive years. (USFWS, 2003)

Recovery Actions:
- Stabilize or increase the population. (USFWS, 2003)
- Protect surface habitat. (USFWS, 2003)
- Monitor contaminants. (USFWS, 2003)
- Collect biological and ecological data on Antrobia culveri that is relevant to achieve the recovery criteria. (USFWS, 2003)
- Initiate educational and public outreach actions to heighten awareness of the Tumbling Creek cavesnail and its important link to good water quality. (USFWS, 2003)
- Develop a participation and implementation plan that will facilitate the timely recovery of the Tumbling Creek cavesnail while minimizing social and economic impacts. (USFWS, 2003)
- Conduct regular reviews. (USFWS, 2003)

Conservation Measures and Best Management Practices:
- Ongoing monitoring of the species' population numbers. (USFWS, 2003)
- Conduct searches for additional populations. (USFWS, 2003)
- Purchase and installation of water quality monitoring equipment in Tumbling Creek.
- Analysis of water samples for possible contaminants. (USFWS, 2003)

- The development of various educational and public outreach material involving caves and cave life. (USFWS, 2003)
- Formation of a Tumbling Creek Work Group and Partnership that includes species experts, Federal and State representatives, contaminant specialists, private land specialists, and private land owners, who will assist in outlining recovery actions for the species. (USFWS, 2003)

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SPECIES ACCOUNT: *Assiminea pecos* (Pecos assiminea snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/09/2005; Southwest Region (R2) (USFWS, 2016)

Physical Description

A minute thermal spring snail of the family Hydrobiidae. See Taylor (1987) for a morphological description.This species was described by Taylor (1987) as a small species with chestnut-brown shell; regularly conical spire with up to 4.5 rounded whorls separated by an incised suture; aperture nearly round, umbilicus contained about 9 times in the shell diameter and only slightly covered by columellar lip. Very small with a thin, nearly transparent chestnut-brown shell that is regularly conical with up to 4.25 strongly incised (shouldered) whorls and a broad oval opening (USFWS, 2005). (NatureServe, 2015)

Current Range

Previously, populations were known from a spring in the Roswell area of the Pecos River Valley in New Mexico, the Diamond Y Spring system in Texas, and at least one site in the Cuatro Cienegas basin in Coahuila, Mexico, with over 600 km between the most distant populations (Taylor, 1987; USFWS, 2005). Hershler et al. (2007) determined that Mexican specimens differ in their morphometry from those of the U.S. and can be diagnosed by several characters and go on to describe Mexican populations as a new species, Assiminea cienegensis. It appears to have been founded by coastal colonists transported on water birds as opposed to a direct connection during Miocene-Pliocene to the sea (Hershler and Liu, 2008).

Critical Habitat Designated

Yes; 8/9/2005.

Legal Description

On June 7, 2011, the U.S. Fish and Wildlife Service designated critical habitat for Assiminea pecos.

Critical Habitat Designation

Approximately 494.7 ac (200.2 ha) in four units in New Mexico and Texas is designated as critical habitat for the Pecos assiminea.

Unit 1: Sago/Bitter Creek Complex. Unit 1 consists of 31.9 ac (12.9 ha) of habitat that was occupied by all four invertebrates (Pecos assiminea (Assiminea pecos), Roswell springsnail (Pyrgulopsis roswellensis), Koster's springsnail (Juturnia kosteri), and Noel's amphipod (Gammarus desperatus)) at the time of listing and that remains occupied at the present time. This unit contains all of the physical and biological features essential to the conservation of these species. Unit 1 is located on the northern portion of the Middle Tract of Bitter Lake National Wildlife Refuge, Chaves County, New Mexico. The designation includes all springs, seeps, sinkholes, and outflows surrounding Bitter Creek and the Sago Springs complex. Habitat in this unit is in need of special management because of threats by subsurface oil and gas drilling or similar activities that contaminate surface drainage or aquifer water; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. The entire unit is owned by the Service.

Unit 2b: Assiminea Impoundment Complex. Unit 2b consists of 18.4 ac (7.4 ha) of habitat that was occupied by the Pecos assiminea at the time of listing and that remains occupied at the present time. This unit contains all of the features essential to the conservation of this species. Unit 2b is located on the southern portion of the Middle Tract of Bitter Lake National Wildlife Refuge and on property owned by the city of Roswell, Chaves County, New Mexico. This unit includes portions of impoundments 7 and 15, and Hunter Marsh. The designation includes all springs, seeps, sinkholes, and outflows surrounding the Refuge impoundments. Habitat in this unit is threatened by subsurface drilling for oil and gas or similar activities that contaminate surface drainage or aquifer water; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. Land ownership in this unit includes the Service and the City of Roswell, New Mexico.

Unit 4: Diamond Y Springs Complex. Unit 4 consists of 441.4 ac (178.6 ha) of habitat that is currently occupied by Pecos assiminea. This unit contains all of the features essential to the conservation of the Pecos assiminea and was occupied by this species at the time of listing. The designation includes the Diamond Y Spring and approximately 4.2 mi (6.8 km) of its outflow, ending at approximately 0.5 mi (0.8 km) downstream of the State Highway 18 bridge crossing. Also included in this unit is approximately 0.5 mi (0.8 km) of Leon Creek upstream of the confluence with Diamond Y Draw. All surrounding riparian vegetation and mesic (wet) soil environments within the spring, outflow, and portion of Leon Creek are also designated, as these areas are considered habitat for the Pecos assiminea. This designation is approximately 441.4 ac (178.6 ha) of aquatic and neighboring mesic habitat. Habitat in this unit is threatened by increased groundwater pumping; subsurface drilling for oil and gas or similar activities that contaminate surface drainage or aquifer water; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. This unit occurs entirely on private lands managed as a nature preserve by The Nature Conservancy.

Unit 5: East Sandia Spring. Unit 5 consists of 3.0 ac (1.2 ha) of aquatic and mesic habitat that is currently occupied by Pecos assiminea. This unit contains all of the features essential to the conservation of the Pecos assiminea and was occupied by this species at the time of listing. East Sandia Spring is at the base of the Davis Mountains just east of Balmorhea, Texas, and is part of the San Solomon-Balmorhea Spring Complex, the largest remaining desert spring system in Texas where the Pecos assiminea is found. The designation includes the springhead itself, surrounding seeps, and all submergent vegetation and moist soil habitat found at the margins of these areas, comprising the physical and biological features for the Pecos assiminea. Habitat in this unit is threatened by increased groundwater pumping; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. This unit occurs entirely on private lands managed as a nature preserve by The Nature Conservancy.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Chaves County, New Mexico, and Pecos and Reeves Counties, Texas. The primary constituent element of critical habitat for the Pecos assiminea is moist or saturated soil at stream or spring run margins:

(i) That consists of wet mud or occurs beneath mats of vegetation;

(ii) That is within 1 inch (2 to 3 centimeters) of flowing water;

(iii) That has native wetland plant species, such as salt grass or sedges, that provide leaf litter, shade, cover, and appropriate microhabitat;

(iv) That contains wetland vegetation adjacent to spring complexes that supports the algae, detritus, and bacteria needed for foraging; and

(v) That has adjacent spring complexes with: (A) Permanent, flowing, fresh to moderately saline water with no or no more than low levels of pollutants; and (B) Stable water levels with natural diurnal and seasonal variations.

Special Management Considerations or Protections

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 the effective date of this rule.

Special management considerations are needed to protect the habitat of this species from the loss or alteration of spring habitat as a result of drought or pumping.

Special management efforts are needed to protect habitat of this species from the potential effects of water contamination from oil and gas operations, agricultural activities, wastewater effluent, and stormwater runoff.

Special management efforts are needed to correctly plan prescribed fires in order to protect habitat of this species from the potential effects of wildfire.

Special management efforts are needed to protect this species from the potential effects of invasive, nonnative terrestrial plants and invasive, nonnative snails.

Life History

Feeding Narrative

Adult: The snails feed on algae, bacteria, and decaying organic matter; and will incidentally ingest small invertebrates while grazing on algae and detritus (USFWS, 2010).; The Roswell springsnail and Koster's springsnail have lifespans of 9 to 15 months and reproduce several times during the spring through fall breeding season (Taylor, 1987; Pennak, 1989). No information exists on frequency of breeding, fecundity, or other aspects of reproduction of Pecos assiminea. (NatureServe, 2015)

Reproduction Narrative

Adult: Pecos assiminea typically reaches sexual maturity within 6 months of age. This species breeds via internal fertilization and fertilized eggs are deposited in egg masses (large gelatinous mat) (National Biological Infrastructure, n.d.). There is limited information on frequency of breeding, fecundity, or other aspects of reproduction of Pecos assiminea.; Assiminea pecos, Juturnia kosteri, Pyrgulopsis roswellensis, and the amphipod Gammarus desperatus are often found together associated with aquifer-fed, spring systems in desert grasslands of the Pecos River basin with abundant "karst" topography (USFWS, 2010). ; (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: The species is associated with aquifer-fed, spring systems in desert grasslands of the Pecos River basin with abundant "karst" topography (USFWS, 2010). It is also found in vegetation dominated by American three-square (Scirpus americanus), common reed (Phragmites australis) and spike rush (Eleocharis spp.) (National Biological Infrastructure, n.d.). Along Bitter Creek, they occur at the water's edge and to a depth of 21 cm (New Mexico Department of Game and Fish, 2004). Taylor (1987) describes the habitat as moist earth beside flowing water (never beside standing water), beneath salt grass or sedges, less often on exposed surfaces. It is a marsh snail that seldom occurs immersed in water but prefers a humid microhabitat created by wet mud or beneath vegetation mats, typically within a few cm of running water (USFWS, 2005; 2010). Riparian (NatureServe, 2015). Clumped arrangements of the population, narrow environmental specificity, high ecological integrity of the community, high site fidelity and low tolerance ranges are based on the species specific habitat requirements, small geographic range and low number of known populations.

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: Unlikely (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: The species has a localized range, very limited mobility, and a fragmented habitat with very poor dispersal capability (USFWS, 2005; 2010); Low mobility and dispersal as well as unlikely immigration are based on the snails specific habitat requirements, isolated populations and physiological characteristics as does the species being classified as non-migrant (NatureServe, 2015).

Population Information and Trends

Population Trends:

No information found

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1000 - 10,000 individuals (NatureServe, 2015)

Adaptability:

The species has a localized range, very limited mobility, and a fragmented habitat with very poor dispersal capability (USFWS, 2005; 2010). (NatureServe, 2015)

Population Narrative:

The species has a localized range, very limited mobility, and a fragmented habitat with very poor dispersal capability (USFWS, 2005; 2010). Probably >10,000 individuals occupying 800 ha (<2,000 acres) of spring run. At Bitter Creek occupies about 0.8 km (0.5 mi) of spring run, and at Diamond Y occupies about 1.5 km (1 mi) of spring and spring run (Taylor, 1987; USFWS, 2005; 2010). Extirpated at two sites in Roswell area. Taylor (1987) originally described the species from New Mexico (a spring at a country club (one dead shell- likely extirpated) and a localized at Lost River (also extirpated 1981-1984) in Chaves Co.), Texas (Diamond Y Draw at Diamond Y Spring downstream for 1 mile in Pecos Co.), and Mexico (playa north of Las Delicias and playa south of Rancho San Marcos in Coahuila both by empty shells only; and Cuatro Cienegas basin on the west and in headwaters of Rio Salado de Los Nadadores- widespread but sparse). The Mexican populations have been attributed to a new species, Assiminea cienegensis by Hershler et al. (2007). A good population exists at Bitter Creek, at Diamond Y Spring system in Texas, Bitter Lake National Wildlife Refuge, Chaves County, New Mexico; however sites in the Cuatro Cienegas basin in Coahuila, Mexico have now been separated as another species (Hershler et al., 2007). The species is currently known from six sites total: four from Bitter Lake National Wildlife

Refuge in Chaves Co., New Mexico, a large population at Diamond Y Spring in Texas and its associated drainage in Pecos Co., and at East Sandia Spring in Reeves Co., Texas (USFWS, 2010). It persists at Diamond Y Spring in Pecos Co., Texas and a previously unknown population was discovered at East Sandia Spring in Reeves Co., Texas on private lands under stewardship of the Nature Conservancy. It also persists at Bitter Lake National Wildlife Refuge in the upper reaches sporadically along Bitter Creek near dragonfly Spring, the lower end of Bitter Creek near Bitter Lake, the lower reaches of the Sago Spring wetland complex near Sinkhole No. 31, on the western perimeter of Impoundment Unit 7, at a spring in the extreme southwestern corner of Impoundment Unit 15, and in some springs adjacent to the Refuge owned by the City of Roswell, New Mexico (NM Game and Fish, 2004; USFWS, 2010). In 2009, a new population was discovered in Hunter's Marsh in New Mexico, near other occurrences (USFWS, 2010). (NatureServe, 2015). Low representation, resiliency and redundancy are based on the species habitat requirements and low number of populations.

Threats and Stressors

Stressor: Reduction of Water in Springs (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: These four invertebrates depend on water for survival. Therefore, the loss or alteration of spring habitat continues to be the main threat to each of the four invertebrates. The scattered distribution of springs makes them aquatic islands of unique habitat in an arid-land matrix (Myers and Resh 1999). Members of the snail family Hydrobiidae (including Roswell and Koster’s springsnails) are susceptible to extirpation or extinction because they often occur in isolated desert springs (Hershler 1989, Hershler and Pratt 1990, Hershler 1994, Lydeard et al. 2004). There is evidence these habitats have been historically reduced or eliminated by aquifer depletion (Jones and Balleau 1996). The lowering of water tables through aquifer withdrawals for irrigation and municipal use has degraded desert spring habitats, which the three snails and Noel’s amphipod depend upon for survival. At least two historic sites for the invertebrates (South Spring, Lander Spring) are currently dry due to aquifer depletion (Cole 1981, Jones and Balleau 1996), and Berrendo Spring, historical habitat for the Roswell springsnail, is currently at 12 percent of the 1880s flow. However, during the mid-1970s, the areas currently occupied by the species continued to flow, even though groundwater pumping was at its highest rate and the area was experiencing extreme drought (McCord et al. 2007). This suggests these springs and seeps may be somewhat resilient to reduced water levels (USFWS, 2010).

Stressor: Water Contamination (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat/loss of individuals
Narrative: Water contamination, particularly from oil and gas operations, is a significant threat for these four invertebrates. In order to assess the potential for contamination, a study was completed in September 1999 to delineate the area that serves as sources of water for the springs on the Refuge (Balleau Groundwater, Inc. 1999). This study reported that the sources of water that will reach the Refuge’s springs include a broad area beginning west of Roswell near Eightmile Draw, extending to the northeast to Salt Creek, and southeast to the Refuge. This area represents possible pathways from which contaminants may enter the groundwater that feeds

the springs on the Refuge. This broad area sits within a portion of the Roswell Basin and contains a mosaic of Federal, State, City, and private lands with multiple land uses including expanding urban development (USFWS, 2010).

Stressor: Fire (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The effects of wildfire to these four invertebrate species could be catastrophic and pose a threat to at least the Roswell and Koster's springsnails and Noel's amphipod. As such, strategically timed prescribed burns throughout their range significantly reduce fuel loads, limiting the risk of detrimental wildfires (USFWS, 2010).

Stressor: Overutilization for commercial, recreational, scientific, or educational purposes (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Roswell springsnail, Koster's springsnail, Pecos assiminea, and Noel's amphipod may occasionally be collected as specimens for scientific study, but these uses have a negligible effect on total population numbers. These species are currently not known to be of commercial value, and overutilization has not been documented. However, as their rarity becomes known, they may become more attractive to collectors. Although scientific collecting is not presently identified as a threat, unregulated collecting by private and institutional collectors could pose a threat to these locally restricted populations. We are aware of overcollection being a potential threat with other snails (e.g., armored snail (Pyrgulopsis (Marstonia) pachyta) (65 FR 10033, February 25, 2000); Bruneau hot springsnail (P. bruneauensis) (58 FR 5938, January 25, 1993); and Socorro springsnail (P. neomexicana) and Alamosa springsnail (Tryonia alamosae) (56 FR 49646, September 30, 1991), due to their rarity, restricted distribution, and generally well known locations. Due to the small number of localities for the four invertebrates, these species are vulnerable to unrestricted collection, vandalism, or other disturbance. There is no documentation of collection as a significant threat to any of the species. Therefore, we believe that collection of the animals is a minor but present threat (USFWS, 2010).

Stressor: Predation (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Springsnails and amphipods are a food source for other aquatic animals. Juvenile springsnails appear vulnerable to a variety of predators. Damselflies (Zygoptera) and dragonflies (Anisoptera) have been observed feeding upon snails in the wild (Mladenka 1992). Damselflies and dragonflies are native and abundant on the Refuge and their aquatic larvae most likely prey upon both the springsnails and Noel's amphipod. Springsnails are vulnerable to predation by fish (Kennedy 1977; Winemiller and Anderson 1997). Mladenka (1992) found that guppies would feed on springsnails in the laboratory. Nonnative fish present on the Refuge (primarily common carp, Cyprinus carpio) most likely also prey upon the springsnails and Noel's amphipod when they occur in the same habitats. The extent to which predation from nonnative fish affects population size of the three aquatic invertebrates is not known. Predation pressure on the semiaquatic

Pecos assiminea is also unknown. However, if the decollate snail (Rumina decollata), a nonnative predatory snail, becomes established on the Refuge, the potential exists for it to prey on Pecos assiminea. The decollate snail was introduced to the United States in the early 1800s in South Carolina and spread westward (Selander and Kaufman 1973). It was reported in Arizona in 1952 and California in 1966 but was well established by the time it was discovered (Selander and Kaufman 1973). It is common in Texas (Selander and Kaufman 1973) and has been reported from the Roswell area in New Mexico (Lang 2005b). It inhabits gardens and agricultural areas and is primarily terrestrial, but has also invaded riparian and other native habitats (Selander and Kaufman 1973). It is used in California as a biological control agent against the brown garden snail (Helix aspera) (Cowie 2001). It will consume native snails (Cowie 2001) as well as vegetation (Dundee 1984). For these reasons, the decollate snail is a potential threat to Pecos assiminea (USFWS, 2010).

Stressor: Predation and competition (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Nonnative aquatic species such as crayfish, fish, and aquatic snails are also a potential threat to the four invertebrates. There are three native and three nonnnative species of crayfish in New Mexico, but their distributions do not overlap with that of the four invertebrates (Hobbs 1991; B. Lang, NMDGF, pers. comm., 2010). Crayfish are typically opportunistic generalists (they will eat anything and everything) (Hobbs 1991) and their predation on invertebrates is well documented (Hobbs 1991; Lodge et al. 1994; Charlebois and Lamberti 1996; Strayer et al. 1999). Additionally, because they also feed on organic debris and vegetation and reduce algal biomass (Charlebois and Lamberti 1996), they could potentially compete with Roswell springsnail, Koster's springsnail, and Noel's amphipod for food resources. Currently nonnative crayfish are not present on the Refuge or the sites in Texas. Diamond Y Springs Complex does have an undescribed native crayfish that we do not believe to be a concern for Pecos assiminea. However, crayfish have created major problems in aquatic systems in Arizona, and there is no physiological reason why some species of crayfish could not survive in the habitats that now support the four invertebrates. Eradication of crayfish once they are established is extremely difficult (Hyatt 2004). Should crayfish become established in habitats occupied by the four invertebrates, crayfish would pose a potential threat via predation and competition. Nonnative fish have had a major impact on native aquatic fauna in the southwest (Minckley and Douglas 1991; Desert Fishes Team 2003). Communities of animals evolved together and developed adaptations to deal with competition and predation from other members of the community (Meffe et al. 1994). When a nonnative species is introduced into this community, the native members often do not have defenses against predation or they may be less successful competitors. As a result, the nonnative species can have a major impact on native populations (Minckley and Douglas 1991; Meffe et al. 1994). Common carp, a nonnative species, is known to co-occur with the three aquatic invertebrates on the Refuge. Native to Asia, common carp was introduced into the United States in 1831, has become widely distributed (Sublette et al. 1990), and is present on the Refuge in habitats occupied by the invertebrates. It is an omnivore that feeds on aquatic invertebrates, fish eggs, algae, plants, and organic matter (Sublette et al. 1990). In addition, through spawning and feeding behavior it uproots vegetation and increases turbidity (Sublette et al. 1990). Because of its non-discriminatory diet and habitat disturbance, the introduced common carp could have an impact on the three aquatic invertebrate species. Mosquitofish (Gambusia affinis) is also present in some of the spring systems on the Refuge, but

it is not known if it is native to the area or not. The species is native to portions of New Mexico, but it has also been widely introduced to control mosquitoes (Sublette et al. 1990). However, it has negatively affected or extirpated many native species of fish and invertebrates (e.g., through predation or hybridization) (Meffe et al. 1994). It is not known if mosquitofish are affecting the three species of aquatic invertebrates (USFWS, 2010).

Stressor: Introduced Species (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Introduced species are one of the most serious threats to native aquatic species (Williams et al. 1989, Lodge et al. 2000). Because the distribution of the four invertebrates is so limited and their habitat is so restricted, introduction of certain nonnative species into their habitat could be devastating. Building upon the list of nonnative aquatic species, such as crayfish, fish, and aquatic snails, discussed under Predation and competition in section 2.3.2.3, below is a discussion of additional nonnative plants and animals that could negatively impact the four invertebrates. Plants Several invasive terrestrial plant species that may affect the invertebrates are present on the Refuge, including saltcedar (Tamarix spp.), common reed, and Russian thistle (tumbleweed) (Salsola spp.). Control and removal of nonnative vegetation is a factor responsible for localized extirpations of populations of Pecos assiminea in Mexico and New Mexico (Taylor 1987), but uncontrolled nonnative vegetation invasion is also likely detrimental to the species. Saltcedar, found on the Refuge and at Diamond Y Spring Complex and East Sandia Spring, threatens spring habitats primarily through displacement of native plants, shading and/or cooling of spring runs, and from the chemical composition of the leaves and sap that drop to the ground and into the springs. Saltcedar leaves that fall to the ground and into the water increase the salinity of the system, as their leaves contain salt glands (DiTomaso 1998). Additionally, dense stands of common reed choke the stream channel, slowing water velocity and creating more pool-like habitat; this habitat is less suitable for Roswell and Koster's springsnails, which prefer flowing water. Finally, Russian thistle (tumbleweed) can create problems in spring systems by being blown into the channel, slowing flow and overloading the system with organic material (Service 2005b). The specific and limited habitat of the four invertebrates is vulnerable to invasion by these introduced plants, posing the potential for habitat degradation by a moderate threat to the four invertebrates. Mollusks Nonnative mollusks have affected the distribution and abundance of native mollusks in the United States. Of particular concern for three of the invertebrates (Noel's amphipod, Roswell springsnail, and Koster's springsnail) is the red-rim melania (Melanoides tuberculatus), a snail that can reach tremendous population sizes and has been found in isolated springs in the west. The red-rim melania has caused the decline and local extirpation of native snail species, and it is considered a threat to endemic aquatic snails that occupy springs and streams in the Bonneville Basin of Utah (Rader et al. 2003). It is easily transported on fishing boats and gear or aquatic plants, and because it reproduces asexually (individuals can develop from unfertilized eggs), a single individual is capable of founding a new population. It has become established in isolated desert spring ecosystems such as Ash Meadows, Nevada, and Cuatro Cienegas, Mexico, and within the last 15 years, the red-rim melania has become established in Diamond Y Springs Complex (Echelle 2001). It has become the most abundant snail in the upper watercourse of the Diamond Y Springs Complex (Echelle 2001). In many locations, this exotic snail is so numerous that it dominates the substrate in the small stream channel. The effect the species is having on native snails is not known; however, because it is aquatic it probably has less effect on Pecos assiminea than on the other endemic aquatic

snails present in the spring. Snails The New Zealand mudsnail (Potamopyrgus antipodarum) is also a potential threat to the endemic aquatic snails on the Refuge and the spring systems in Texas. It was discovered in the Snake River, Idaho, in the mid-1980s and has quickly spread to every Western state except New Mexico (Montana State University 2010). Like the red-rim melania, the New Zealand mudsnail has an operculum (a lid to close off the shell opening), can withstand periods of drying up to eight days (thereby facilitating transport) and can reproduce either sexually or asexually. Thus, new populations can be established with transport of a single individual. In addition, the New Zealand mudsnail is tiny (3 mm [0.12 in] in height), is easily overlooked on gear or shoes, and can be transported unknowingly by people visiting various recreational sites. Considering its current rate of expansion and the availability of suitable habitat, it is highly likely that the New Zealand mudsnail will soon be discovered in New Mexico. The New Zealand mudsnail tolerates a wide range of habitats, including brackish water. Densities are usually highest in systems with high primary productivity, constant temperatures, and constant flow (typical of spring systems). It has reached densities exceeding 500,000 per square meter (46,400 per square foot) (Richards et al. 2001) to the detriment of native invertebrates. Not only can it dominate the invertebrate assemblage (97 percent of invertebrate biomass), it can also eat nearly all of the algae and diatoms growing on the substrate, altering ecosystem function at the base of the food web (food is no longer available for native animals) (Hall et al. 2003). If the New Zealand mudsnail is introduced into the spring systems harboring the four invertebrates, control would most likely be impossible because the snails are so small and because any chemical treatment would also affect the native species. The impact could be devastating. Trematodes Infestation by trematodes (a flatworm or fluke, phylum Platyhelminthes) was noted by Taylor (1987) in populations of Koster's springsnail at Sago Spring on the Refuge. Digenetic trematodes (trematodes in the order Digenera) are parasitic and have the most complicated life histories in the animal kingdom involving two to four intermediate (vertebrate and/or invertebrate) hosts (Hickman et al. 1974). The first larval stage of the trematode nearly always uses a mollusk (snail or bivalve) as the first intermediate host (Hickman et al. 1974). Larval trematode parasites reduce or completely inhibit snail reproduction through castration (Minchella et al.1985). The effect of the trematodes on the springsnail population is not known (USFWS, 2010).

Stressor: Population Dynamics (USFWS, 2010)
Exposure:
Response:
Consequence: Exctinction
Narrative: Several biological traits have been identified as putting a species at risk of extinction (McKinney 1997, O'Grady et al. 2004). Some of these characteristics include having a localized range, limited mobility, and fragmented habitat (Noss et al. 2006, Fagan et al. 2002). The four invertebrate species each have all of these characteristics. Having a small, localized range means that any perturbation (e.g., drought, water contamination) can eliminate the species. Having a high number of individuals at a site provides no protection against extinction. Noel (1954) noted that Noel's amphipod in Lander Spring, New Mexico was the most abundant animal present when she did her research. The species was extirpated from that site when the spring dried up (Cole 1985). Extremely limited dispersal capability effectively eliminated the ability of the amphipod to find and disperse to other suitable habitats or to move out of habitat that becomes unsuitable. Consequently, the amphipod and snails are unable to avoid pollution or other unfavorable changes to their habitat. Severe drought or wildfire, groundwater pollution and

spring contamination, or spring development (impoundment, dredging, piping) could result in the extirpation or extinction of the species (USFWS, 2010).

Stressor: Climate Change (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Increased air temperatures lead to higher evaporation rates, which may reduce the amount of runoff, groundwater recharge, and consequently spring discharge. Increased temperatures across the southwest may also increase the extent of area influenced by drought (Lenart 2003), decreasing groundwater recharge regionally, thereby reducing spring discharge. Prolonged drought leading to diminishment or drying of the spring would have a negative impact on the four invertebrates. Springs would not have to dry out completely to have an adverse effect. Decreased spring flow could lead to a decrease in the amount of suitable habitat, increased water temperature fluctuations, lower dissolved oxygen levels, and an increase in salinity (MacRae et al. 2001). In addition, as water becomes increasingly scarce, conflict over its use becomes more intense. Human and cattle consumption of water would be expected to increase during drought. Any of these factors, alone or in combination, could lead to either the reduction or extirpation of the populations. Thus, climate change is a significant threat to these four invertebrate species into the foreseeable future (USFWS, 2010).

Recovery

Recovery Actions:
- A Recovery Plan has not been developed for this species.

Conservation Measures and Best Management Practices:
- Develop a recovery plan for these species. The State of New Mexico has a recovery plan that has helped guide conservation efforts; however, a recovery plan with measurable objectives and criteria needs to be developed by the Service to provide delisting goals (USFWS, 2010).
- Continue investigation of Noel's amphipod population genetics to determine the species' status on the Refuge (USFWS, 2010).
- Continue investigation of the effects of fire on the Pecos assiminea to determine methods of burning an occupied area while protecting the population (USFWS, 2010).
- Secure conservation on additional lands surrounding occupied habitat to protect water quality and improve land management practices (USFWS, 2010).
- Continue to manage Refuge lands to reduce invasive plants (USFWS, 2010).

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SPECIES ACCOUNT: *Athearnia anthonyi* (Anthony's riversnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; April 15, 1994; Southeast region (R4)

Physical Description

The species grows to about 2.5 centimeters (1 inch) in shell length (base to top of spire). Its shell is ovate and olive green to yellowish brown in color, with variable purplish or brownish bands that encircle the body whorl (largest whorl). The shell spire is short and has about four whorls, though often those above the body whorl are badly eroded. The body whorl of adults is strongly shouldered (carinate), with a series of large, irregular, obtuse tubercles. The tubercles are often little more than broad undulations of the shoulder. The shell aperture is ovate with a thin outer lip, often with some purple coloration within. The columellar lip is reflected so that it partially or entirely covers a deep umbilical depression (adapted from Gordon 1991). Juvenile Anthony's riversnails are distinct, being as wide (measured across the aperture) as they are long, with pointed spires and bases. This shape, along, with a heavy carina, gives them a saucer-shaped appearance. As an individual grows, the carina gradually disappears, and the shell attains dimensions that are greater in length than width (USFWS, 1997).

Taxonomy

Formerly placed as a subspecies of Leptoxis (= Athearnia) crassa (see Dillon and Ahlstedt, 1997). Athearnia crassa crassa and Athearnia crassa anthonyi are distinct from one another and Athearnia anthonyi and Athearnia crassa are now recognized as distinct species (see Dillon and Ahlstedt, 1997; Minton and Savarese, 2005) (Natureserve, 2015)

Historical Range

Historically distributed from the lower French Broad and Clinch rivers to the vicinity of Muscle Shoals, this species was originally described from the Holston River near Knoxville, Tennessee (USFWS, 1996). It was once widespread in the Tennessee River system, where it was associated with shoal areas in the main stem of the Tennessee River from Knoxville (Knox Co., Tennessee) downstream to Muscle Shoals (Colbert and Lauderdale Cos., Alabama) and lower reaches of its tributaries in eastern Tennessee, northern Alabama, and northwestern Georgia (USFWS, 1996). Extirpated from much of the Tennessee River and tributaries following impoundment (NatureServe, 2015)

Current Range

Presently known from the extreme lower sections of only four streams: a stretch of the Sequatchie and Little Sequatchie Rivers, Marion County, Tennessee; Limestone Creek, Limestone County, Alabama, and in the main channel of the Tennessee River near the Alabama and Tennessee state line (Mirarchi et al., 2004; Minton and Savarese, 2005). Populations all found to be genetically distinct from one another (Minton and Savarese, 2005; TN NHP, pers. comm., 2007) (NatureServe, 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: No information found

Reproduction Narrative

Adult: Assumed to be oviparous (as other Pleuroceridae). It probably lays eggs only for a very short period annually. New recruits appear between May and July with many individuals suspected of having at least two breeding seasons (Garner and Haggerty, 2010) (USFWS, 2015).

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Habitat Narrative

Adult: The species prefers medium to large river habitats with cobble/boulder substrates in the vicinity of riffles with strong current (USFWS 1997; USFWS, 2011).High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 2012; 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

Immigration/Emigration

Adult: Unlikely

Dispersal/Migration Narrative

Adult: Actively crawls across benthic substrates, probably more commonly on hard surfaces rather than mud or sand. Probably does not display any sort of seasonal migration, but may display circadian responses (NatureServe, 2015).Dispersal and immigration/emigration are inferred based on habitat.

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low

Representation:

Low

Redundancy:

Low

Number of Populations:

1 to 20 (NatureServe, 2015)

Population Size:

10,000 to >100,000 (NatureServe, 2015)

Population Narrative:

Short-term Trend: Decline of 10-30% NatureServe, 2015).Resiliency, representation and redundancy are inferred based on habitat and taxonomy.

Threats and Stressors

Stressor: Habitat destruction/modification from human-induced siltation
Exposure:
Response:
Consequence:
Narrative: Although habitat destruction results from a variety of human-induced impacts such disturbance of riparian corridors, and changes in channel morphology continues to impact the Anthony's riversnail, the most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). Activities that contribute sediment discharges into a stream system change the erosion or sedimentation pattern, which can lead to the destruction of riparian vegetation, bank collapse, excessive instream sediment deposition, and increased water turbidity and temperatures (Waters 1995). The effects of these types of threats will likely increase as human populations grow in the Tennessee River watershed in response to human demands for water, housing, transportation, and places of employment.

Stressor: Human-induced non-point and source pollution, including herbicides and pesticides
Exposure:
Response:
Consequence:
Narrative: Non-point source pollution from land surface runoff can originate from virtually any land use activity (such as land development and agricultural activities) and may be correlated with impervious surfaces and storm water runoff from urban areas. Pollutants may also originate from spills (for further information see Factor E). Pollutants entering the Sequatchie and

Tennessee rivers and Limestone Creek may include sediments, 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 streams such that the habitat and food sources for species like the Anthony's riversnail are negatively impacted.

Stressor: Inadequate existing regulatory mechanisms
Exposure:
Response:
Consequence:
Narrative: The Anthony's riversnail and its habitats are afforded limited protection from water quality degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.) and the Tennessee Water Quality Control Act of 1977. 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 snail. Since listing, section 7 of the Act has required Federal agencies to consult with the Service when projects they fund, authorize, or carry out may affect the species. However, the lack of Federal authority over the many actions likely impacting Anthony's riversnail habitat has become apparent. Many of the threats (including those identified at the time of listing, during recovery planning, and since development of the Recovery Plan) involve activities that likely do not have a Federal nexus (such as water quality changes resulting from development, water withdrawals, or logging) and, thus, may not result in section 7 consultation.

Stressor: Stochastic catastrophic events, such as chemical spills
Exposure:
Response:
Consequence:
Narrative: The Anthony's riversnail's limited geographic range and apparent small population size leaves the species extremely vulnerable to localized extinctions from accidental toxic chemical spills or other stochastic disturbances and to decreased fitness from reduced genetic diversity. Potential sources of such spills include potential accidents involving vehicles transporting chemicals over road crossings of streams inhabited by the snail and accidental or intentional release into streams of chemicals used in agricultural or residential applications.

Stressor: Loss of genetic diversity due to small population
Exposure:
Response:
Consequence:
Narrative: The Anthony's riversnail's small population size naturally makes it vulnerable to losses in genetic diversity and fitness. 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).

Recovery

Reclassification Criteria:

Anthony's riversnail will be considered for reclassification to threatened status when the likelihood of the species' becoming extinct in the foreseeable future has been eliminated by achievement of the following criteria:

1. Through protection of existing populations and through the successful establishment of reintroduced populations or the discovery of additional populations, a total of four distinct viable will populations exist. These four populations shall be distributed throughout a significant portion of the species' historic range (USFWS, 1997).

2. At least two distinct, naturally reproduced year classes exist within each of the four populations. One of these year classes must have been produced within the 2 years prior to the time the species is reclassified from endangered to threatened (USFWS, 1997).

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 a significant increase in population density and/or an increase in the length of the river reach inhabited by each of the four populations (USFWS, 1997).

4. Where habitat has been degraded, noticeable improvements in water and/or substratum quality have occurred (USFWS, 1997).

5. Each of these four populations and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence (USFWS, 1997).

6. All four populations remain stable or increase over a period of at least 10 years (USFWS, 1997).

Delisting Criteria:
Anthony's riversnail will be considered for removal from Endangered Species Act protection when the likelihood of the species' becoming threatened in the foreseeable future has been eliminated by the achievement of the following criteria (USFWS, 2011):

1. Through protection of existing populations and through the successful establishment of reintroduced populations or the discovery of additional populations, a total of six distinct viable populations will exist. These populations shall be distributed throughout a significant portion of the species' historic range (USFWS, 2011).

2. Two distinct, naturally reproduced year classes exist within each of the six populations. One of these year classes must have been produced within the 2 years prior to the recovery date (USFWS, 2011).

3. Studies of the snail's biological and ecological studies have been completed, and recovery measures developed and implemented from these studies have proven successful, as evidenced by a significant increase in population density and/or an increase in the length of the river reach inhabited by each of these six populations (USFWS, 2011).

4. Where habitat has been degraded, noticeable improvements in water and/or substratum quality have occurred (USFWS, 2011).

5. Each of these six populations and their habitats are protected from any present and foreseeable threats that would jeopardize their continued existence (USFWS, 2011).

6. All six populations remain stable or increase over a period of at least 10 years (USFWS, 2011).

Recovery Actions:

- Protect existing populations through reduction/elimination of threats to habitat, such as efforts to reduce non-point pollution from agricultural activities (USFWS 2011).
- Protect habitat through the utilization of existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.)(USFWS 2011).
- Establish reintroduced populations or discover additional naturally-occurring populations such that either a total of four distinct viable populations exist (for downlisting) or six populations (for delisting). 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 (see below) (USFWS 2011).
- Through monitoring, determine the number of individuals and the amount and quality of habitat required to meet the criterion of a viable population (see above). Any experimental populations that are established through augmentation should be monitored genetically and population growth noted to be compared with non-augmented populations to determine whether fitness is enhanced or diminished from the introduction of unique haplotypes from other populations (Minton and Savarese 2005)(USFWS 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS - Continue to monitor population levels at all three populations (Tennessee River, Sequatchie River, and Limestone Creek), demographics, and habitat conditions of existing populations, especially the Tennessee and Sequatchie river populations. Continue efforts aimed at obtaining individuals and improving techniques necessary for captive propagation of the species. Any experimental populations that are established through augmentation should be monitored genetically and population growth noted to be compared with non-augmented populations to determine whether fitness is enhanced or diminished from the introduction of unique haplotypes from other populations (Minton and Savarese 2005). As identified by the Cumberlandian Region Mollusk Restoration Committee (CRMRC), priority actions for the species include: continue reintroductions into Wilson Dam tailwater, complete updated survey efforts in the Sequatchie River, and determine if translocations into the Nolichucky River are warranted (CRMRC 2009). The CRMRC (2009) lists the Wilson Dam tailwater NEP, the lower French Broad and Holston rivers NEP, and the Nolichucky River as potential reintroduction streams. Any translocations that are conducted should use the Limestone Creek population as it is the most robust and has been more closely monitored (Garner and Haggerty 2010). Minton and Savarese (2005) further suggest that only juveniles be involved in translocations as they are easier to identify. 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. Continue to work with the Tennessee Valley Authority to ensure that operations at Nickajack Dam remain protective of the species and its large river habitat downstream from the dam. Continue efforts to reduce non-point pollution from agricultural activities by working through the Partners for Fish and Wildlife, Farm Bill, and other landowner incentive programs to implement best management practices (USFWS, 2018).

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SPECIES ACCOUNT: *Campeloma decampi* (Slender campeloma)

Species Taxonomic and Listing Information

Listing Status: Endangered; February 25, 2000; Southeast region (R4)

Physical Description

The shell is medium to large in size and typically between 5 mm to 35 mm in length (ARC 1997, 65 FR 10033). The slender campeloma is identified in the field by its larger size for this type of snail, ovately conic shell, and tapered pointed spire (Burch 1989, Garner 2004b) (USFWS, 2012).

Taxonomy

The slender campeloma was originally described as Melantho decampi (see Figure 1 for original plate), for its discoverer W. H. DeCamp (Binney 1865). It is a medium to large (generally less than 35 mm) snail of the ovoviviparous family Viviparidae (65 FR 10033). Clench and Turner (1955) suggest that the type locality for the species is Decatur, Alabama, and that the type locality given by Binney (1865) in the original description (Huntsville or Stevenson) was in error. Clench and Turner (1955) state that the original label on the specimens by W. H. DeCamp lists Decatur, Alabama, as the locality. (USFWS, 2012).

Historical Range

Previously known to occur only within three short stream reaches in Limestone, Piney, and Round Island Creeks (Figure 2) (USFWS, 2012).

Current Range

Recent surveys have expanded the range (Figure 2) of the slender campeloma into Beaverdam Creek, Limestone County, Alabama (Campbell pers. comm. 2007), the Flint River, Madison County, Alabama (AST 2007), and Cypress Creek in Lauderdale County, Alabama (Garner pers. comm. 2012). A 2012 survey by AST Environmental also provided a range extension within the Piney Creek drainage, documenting a population within the lower extent of Little Piney Creek above the crossing at Huntsville Browns Ferry Road (AST 2012) (USFWS, 2012).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: While the food habits of the slender campeloma are not known, it is thought that they most likely feed on detritus (65 FR 10033) (USFWS, 2012). Periphyton is note as a food source (NatureServe, 2015).

Reproduction Narrative

Adult: Relatively little is known about life history and ecology of the slender campeloma. The slender campeloma belongs to the family Viviparidae and as with other members of this family, they are live bearers, giving live birth instead of laying eggs (65 FR 10033) (USFWS, 2012).

Spatial Arrangements of the Population

Adult: Clumped (inferred from USFWS, 2012 and NatureServe, 2015).

Environmental Specificity

Adult: Narrow/specialist (inferred from USFWS, 2012 and NatureServe, 2015).

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2012 and NatureServe, 2015).

Site Fidelity

Adult: High (inferred from USFWS, 2012 and NatureServe, 2015).

Habitat Narrative

Adult: The slender campeloma is typically found burrowing in soft sediments (sand or mud) or detritus (ARC 1997) (USFWS, 2012). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 2012; NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2012 and NatureServe, 2015).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS, 2012 and NatureServe, 2015).

Dispersal

Adult: Low (inferred from USFWS, 2012 and NatureServe, 2015).

Immigration/Emigration

Adult: Unlikely (inferred from USFWS, 2012 and NatureServe, 2015).

Dispersal/Migration Narrative

Adult: Low mobility/motility and dispersal are inferred based on taxa and habitat information as are non-migratory and low dispersal status (USFWS, 2012; NatureServe, 2015)

Population Information and Trends

Population Trends:

Decreasing (inferred from USFWS, 2012 and NatureServe, 2015).

Resiliency:

Low (inferred from USFWS, 2012 and NatureServe, 2015).

Representation:

Low (inferred from USFWS, 2012 and NatureServe, 2015).

Redundancy:

Low (inferred from USFWS, 2012 and NatureServe, 2015).

Population Growth Rate:
Declining (inferred from USFWS, 2012 and NatureServe, 2015).

Number of Populations:
1 to 5 (NatureServe, 2015)

Population Size:
Unknown (NatureServe, 2015)

Adaptability:
Low (inferred from USFWS, 2012 and NatureServe, 2015).

Population Narrative:
Decreasing population trends and number of populations is noted in NatureServe (2015). Resiliency, Representation and Redundancy are inferred based on population size and habitat requirements (USFWS, 2012; NatureServe, 2015).

Threats and Stressors

Stressor: Increased development (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Increased development is listed as a threat to this species (USFWS, 2012).

Stressor: Indiscriminant logging (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Indiscriminant logging is listed as a threat to this species (USFWS, 2012).

Stressor: Agriculture (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Agriculture is listed as a threat to this species (USFWS, 2012).

Stressor: Unregulated water withdrawals (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Unregulated logging is listed as a threat to this species (USFWS, 2012).

Stressor: Road and bridge construction (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat

Narrative: Road and bridge construction are listed as threats to this species (USFWS, 2012).

Stressor: Open cut trenching (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Open cut trenching is listed as a threat to this species (USFWS, 2012).

Stressor: Point and non-point pollution discharges (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Point and non-point pollution discharges are listed as threats to this species (USFWS, 2012).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan

References

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SPECIES ACCOUNT: *Discus macclintocki* (Iowa Pleistocene snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 8/2/1978; Great Lakes-Big Rivers Region (R3) (USFWS, 2015)

Physical Description

The Iowa Pleistocene snail is small (6-8 mm wide) with a dome-shaped, tightly coiled shell. The shell is brown or greenish. Ribs are relatively fine and confined to the upper half of each whorl. The species has a moderate-sized umbilicus and lacks a parietal callus. (USFWS, 1991)

Historical Range

No recent occurrences are known outside the algific talus slope areas. Fossil occurrences are known in northeast Iowa, northwest Illinois, southeast Minnesota, and southwest Wisconsin (Henry, 2003). See also Frest (1987). (USFWS, 2013)

Current Range

Presently in only about 22 (updated to 37 talus slopes in Henry, 2003 and 38 in USFWS, 2013) small areas in northeast Iowa and northwest Illinois, and 50% of the individuals are in 4 colonies. Only about 40,000 individuals remain and this density varies from year to year. (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: The Iowa Pleistocene snail has a rather limited diet. It prefers white and yellow birch leaves and those of hard maples, trees with limited distribution in Iowa. It will also eat dogwood and willow leaves, but refuses a wide variety of food sources commonly utilized by other land snails (Frest, 1981). All of the mentioned forage species are found preferentially on rich algific slopes in the Driftless Area. (USFWS, 1984)

Reproduction Narrative

Adult: Breeding season in laboratory colonies is from January to August; however, observed breeding in the wild seems confined essentially to the period from late March-April to August. Like most North American land snails, the Iowa Pleistocene snail is hermaphroditic but not self-fertilizing (Pilsbry 1948) and all adults can apparently both lay eggs and fertilize others. Length of the period from copulation to egg laying is not known, but multiple broods from the same individual each year are common. Clutch size varies from two to six, with three being typical. Hatching occurs about 28 days after eggs are laid. Viability is high with better than 90% commonly hatching. (USFWS, 1984)

Geographic or Habitat Restraints or Barriers

Adult: Lack of cold air (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Very narrow specialist (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Dependency on Other Individuals or Species for Habitat

Adult: No (inferred from NatureServe, 2015)

Habitat Narrative

Adult: This species lives on algific talus slopes, usually north facing, covered with a talus layer and upland sinkholes; lives in leaf litter (Henry, 2003). Algific slopes, usually north facing, occur where air circulates over underground ice producing a constant stream of cold moist air through vents on to the slope. These vents are typically covered with a loose talus layer and thin plant and litter cover. Many rare plant and animal species that are considered glacial relicts persist only on these small areas of suitable habitat. (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: Minimal (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: Unlikely (USFWS, 2013)

Dependency on Other Individuals or Species for Dispersal

Adult: Birds and mammals (USFWS, 2013)

Dispersal/Migration Narrative

Adult: Clark et al. (2008) found horizontal movement was minimal within the algific site habitat over a six year study (about 16.7 meters in one year). (NatureServe, 2015) Dispersal mechanisms for the Iowa Pleistocene snail during interglacial periods are speculative. Currently, individual snails may he washed or carried in the wind into down gradient locations from storms. Animals may carry snails either in their grasp or inadvertently on their body to cover greater distances. Birds, as carriers, are viewed as a dispersal mechanism for the island biogeography of land snails (Vaguolgyi 1975). Wada et al. (2012) found that snails can pass through the guts of birds alive. Shrews also capture and cache live land snails in burrows for reserved food resources (Ingram 1942). It is possible for individuals from one location to be held in a shrew cache near another location, only to escape arid immigrate into the new population. (USFWS, 2013)

Population Information and Trends

Population Trends:
Decline of <70% to Relatively Stable (NatureServe, 2015)

Species Trends:
Decline of <70% to Relatively Stable (NatureServe, 2015)

Resiliency:
Low (Inferred from USFWS, 2013)

Representation:
Low (Inferred from USFWS, 2013)

Redundancy:
Moderate (inferred from USFWS, 2013)

Number of Populations:
38 (USFWS, 2013)

Population Size:
10,000 - 100,000 individuals (NatureServe, 2015)

Adaptability:
Low (inferred from USFWS, 2013)

Population Narrative:
The number of known colonies has increased from 19 to 38 since issuance of the recovery plan in 1984 (USFWS, 1984; 2009, 2013). Although a monitoring program has been developed, data to this point does not indicate whether populations are stable. It will be difficult to extrapolate population trends from one site to the entire snail population because of the extreme variation between sites and the highly divided nature of snail populations within sites (USFWS, 2009). In a mark recapture study over six years at eight algific slope sites in Iowa, Clark et al. (2008) found average density among years at the recapture sample locations was 26 snails per square meter on one site, 51 snails per square meter on another site, and 583 snails per square meter on another site. Most populations were represented by a high percentage (average 86%) of mature individuals. The demographic analyses of Clark et al. (2008) support the previously expressed view that genetic diversity remains relatively high in these snail populations. Many populations are highly subdivided and only a few talus slopes have decent viable populations. Population numbers vary from year to year (Clark et al., 2008). (NatureServe, 2015; USFWS 2013))

Threats and Stressors

Stressor: Clearing of algific talus slopes (NatureServe, 2015)
Exposure:
Response:
Consequence:

Narrative: The algific slopes where these snails live are fragile because of their steepness and loose rock covering. Activity on a site can dislodge rocks and soil, compact surface vents and crush snails. Development (primarily rural house building) has increased in northeast Iowa since the issuance of the 1984 recovery plan and 1991 5-year review; some sites are highly desirable as there tend to be scenic ridges above the algific slopes. Road building was a concern (USFWS, 1984) but apparently has abated, if not stopped. (USFWS, 2013) In addition, most snail sites are located directly above streams that are subject to flash flooding causing erosion of the algific slopes. (NatureServe, 2015)

Stressor: Trampling (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Recreational hiking, scientific investigations, and educational programs have the potential to over utilize algific slopes resulting in trampling from human foot traffic and dislodging of the fragile bryophyte cover over the thin soil and rock surfaces. (USFWS, 2013) While most livestock threats have been alleviated by working with landowners to fence their sites, deer populations have greatly increased since the recovery plan was written and may impact some algific slopes with increased trails and trampling. (NatureServe, 2015)

Stressor: Chemical contamination (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The exposure pathway to the Iowa Pleistocene snail and its habitat is through application of pesticides or pesticides that drift over native habitats, or from pesticides that have volatilized and re-deposited in the rainfall (Hatfield et al. 1996). Other atmospheric pollutants such as nitrogen and mercury may also be deposited at the algific slopes due to their higher elevation and for aspects that face prevailing wind conditions. The soil, detritus, and leaf litter may contain elevated concentrations of heavy metals given the environmental history of lead and zinc mining in the Driftless Area and heavy metals can enrich soils and accumulate in biological tissues. (USFWS, 2013)

Stressor: Global climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: This snail is a glacial relict species; the Recovery Plan indicated that the species is only likely to expand during continental glacial periods (USFWS 1984). Prediction climate models for Iowa indicate an annual rise in temperatures especially during the winter, increase of extreme precipitation, and increase in humidity (Iowa Climate Change Impacts Committee 2011). The climate changes predicted for over the next few decades for Iowa do not necessarily change the cold microclimate conditions on the algific talus slopes that support the Iowa Pleistocene snail. The winter conditions under the climate change scenarios may still produce sufficient quantities of ice deep in the talus through winter precipitation for circulation of cold air well into the summer months. The occupied algific talus slopes are north or northwest facing so they are more shaded from direct sunlight and solar heating to help sustain the deep ice deposits that produce the cold air. Warming climate in the current species range of the Iowa Pleistocene snail may first

make the algific talus slopes in the southern part of the species range less suitable. The evolutionary rate of dispersion for colonization into new suitable habitat (e.g., further north) may not be sufficient with modern human induced climate change in a highly fragmented landscape without intervention (Walther et al, 2002). (USFWS, 2013)

Stressor: Invasive species (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Invasive plant species have encroached into the habitats of the Iowa Pleistocene snail (Cathy Henry. U.S. Fish and Wildlife Service, Wapello, Iowa. pers. comm., 2013). The invasive plant species include garlic mustard and stinging nettle. Competition for nutrients and light by the invasive plant species over the natural climate relict plant assemblage of bryophytes, golden saxifrage and Canada yew may have yet undetermined adverse effects on the suitability of the habitat for the Iowa Pleistocene snail (C. Henry, pers. comm., 2013). (USFWS, 2013)

Recovery

Reclassification Criteria:
The Iowa Pleistocene snail can be considered for reclassification from endangered to threatened status if permanent protection of 16 of the existing colonies (locations) can be achieved and documentation of stable or increasing populations at these sites can be provided by a monitoring program. (USFWS, 2013)

Delisting Criteria:
Delisting of the species can be considered if documentation of stringent protection for at least 24 or more sufficiently dispersed viable breeding colonies (populations) is obtainable. (USFWS, 2013)

Recovery Actions:
- Protection is needed for existing habitats, i.e., algific talus slopes, which support the Iowa Pleistocene snail. Additional potential habitat needs to be surveyed for additional occurrences of the snail. (USFWS, 2013)
- Population protection and management is necessary. Once protected, periodic monitoring is necessary to determine if conservation efforts are succeeding or should be modified. Additional research should be conducted on life history aspects including breeding conditions, tolerances to environmental conditions, life span, forage preferences, effects of environmental contaminants. A laboratory breeding colony should be maintained both for research and for potential reintroductions. (Frest, 1984)
- Information outreach and education should include informing various public agencies of the need to conserve the snail and its habitat, to provide status information to landowners of colony sites, and to educate the general public. (Frest, 1984)

Conservation Measures and Best Management Practices:
- Review and revise the National Iowa Pleistocene Snail Recovery Plan arid include operational definitions for the terms "colony'', "protected”, and "stable" population. The review should consider the threat of global climate change and whether it is necessary to include new objectives to mitigate this threat. (USFWS, 2013)

- Initiate periodic, rotational snail presence - absence surveys on the accessible reaches of the protected slopes to determine population status for making recovery decisions. Some parts of the talus slopes are too fragile or steep to approach easily by foot without causing injury to the surface. Surveys on private land slopes are encouraged. Relate the number of colonies to geographical, geological, metrological, and ecological parameters. The survey methods should be based on inputs from population ecologists and geneticists. (USFWS, 2013)
- Support the genetics study by the Iowa State University by providing sufficient numbers of individuals for testing to help determine viable population size, subpopulation structure, and genetic diversity throughout the species range. (USFWS, 2013)
- Inspect the occupied algific talus slopes with qualified biologists, geologists, and meteorologists to determine the need and size of upland buffer requirements to preserve the cold air circulation. Determine the potential for site specific threats such as invasive species impacts, encroachment, and human disturbance. Create a conservation atlas of each protected occupied slope and upland area that includes air photographs, topographic maps. LiDAR images, site photographs, and site specific geology, biology, ecology, ecosystem data and information plus specific threats for mitigation and conservation planning. (USFWS, 2013)
- Attempt to secure protection of at least six more algific talus slopes on private lands especially in the south and southeastern portions of the species range. This will bring the current number of 18 protected algific talus slopes to the delisting criterion threshold of a total of 24 protected algific talus slopes. Develop an inventory and prioritization of landowners willing to participate in conservation programs for algific talus slope protection. (USFWS, 2013)
- Start an artificial propagation program at reputable hatcheries, zoos, or aquariums to augment existing populations and introduce the species into new suitable habitats, Augmentation appears to be an appropriate recovery action given that recruitment significantly contributes to the population size on low population algific talus slopes. The artificial propagation program will also serve as an educational and outreach tool to help build sentiment for the conservation of cold air talus slopes, glacial relict species, disjunct species, and biodiversity. (USFWS, 2013)

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SPECIES ACCOUNT: *Elimia crenatella* (Lacy elimia (snail))

Species Taxonomic and Listing Information

Listing Status: Threatened; October 28, 1998; Southeast region (R4)

Physical Description

The lacy elimia is a small species in the family Pleuroceridae. Growing to about 1.1 centimeters (cm) (0.4 in) in length, the shell is conic in shape, strongly striate, and often folded in the upper whorls. Shell color is dark brown to black, often purple in the aperture, and without banding. The aperture is small and ovate. The lacy elimia is easily distinguished from other elimia species by a combination of characters (i.e., size, ornamentation, color) (USFWS, 2005).

Taxonomy

In a recent genetic sequence study of the 16S rRNA gene, the lacy elimia was found to be very similar to the compact elimia (Elimia showalteri) (Lydeard et al., 1997). Despite their apparent close genetic relationship, the authors made no suggestion that the two species represented a single species. The two species are allopatric (do not overlap in distribution--the compact elimia occurs in the Cahaba River, whereas the lacy elimia is found in the Coosa River drainage), and are strikingly different in size, appearance, and behavior. The compact elimia has a large, robust, smooth shell boldly colored brown and/or green, whereas the lacy elimia has a small, delicate, darkly colored, and ornamented shell. The lacy elimia is one of the few elimia snails in the Basin that does not exhibit clinal variation (Goodrich, 1936). In addition, compact elimia are found grazing individually throughout shoal habitats, whereas the lacy elimia is usually found in tight clusters or colonies on larger rocks within a shoal (P. Hartfield, pers. obsv.). Allopatry, morphology, and behavior are strong characters supporting species status of the lacy elimia (USFWS, 2005).

Historical Range

The lacy elimia was historically abundant in the Coosa River main stem from St. Clair to Chilton County, Alabama, and was also known in several Coosa River tributaries--Big Will's Creek, DeKalb County; Kelley's Creek, St. Clair County; and Choccolocco and Tallaseehatchee Creeks, Talladega County, Alabama (Goodrich, 1936). Currently, the lacy elimia is only known to survive in three Coosa River tributaries--Cheaha, Emauhee, and Weewoka Creeks, Talladega County, Alabama (Bogan and Pierson, 1993a) (USFWS, 2005).

Current Range

The species is locally abundant in the lower reaches of Cheaha Creek. This stream originates within the Talladega National Forest; however, no specimens of the lacy elimia have been collected on Forest Service lands. The species has also been found at single sites in Emauhee and Weewoka creeks, where specimens are rare, and difficult to locate (USFWS, 2005).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Most species graze on periphyton (attached algae) growing on benthic (bottom) substrates (USFWS, 2005).

Reproduction Narrative

Adult: Eggs are laid in early spring and hatch in about 2 weeks. Snails apparently become sexually mature in their first year, but, in some cases, females may not lay eggs until their second year. Some elimia species may live as long as 5 years (Dillon, 1988) (USFWS, 2005).

Spatial Arrangements of the Population

Adult: Clumped (inferred from USFWS, 2005; NatureServe, 2015).

Environmental Specificity

Adult: Narrow/specialist (inferred from USFWS, 2005; NatureServe, 2015).

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2005; NatureServe, 2015).

Site Fidelity

Adult: High (inferred from USFWS, 2005; NatureServe, 2015).

Habitat Narrative

Adult: Little is known specific to the lacy elimia, however, elimia snails are gill-breathing snails that typically inhabit highly oxygenated waters on rock shoals and gravel bars (USFWS, 2005). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 2005; NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2005; NatureServe, 2015).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS, 2005; NatureServe, 2015).

Dispersal

Adult: Low (inferred from USFWS, 2005; NatureServe, 2015).

Immigration/Emigration

Adult: Unlikely (inferred from USFWS, 2005; NatureServe, 2015).

Dispersal/Migration Narrative

Adult: Low mobility/motility and dispersal are inferred based on taxa and habitat information as are non-migratory and low dispersal status (USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:
Low (inferred from NatureServe, 2015)

Representation:
Low (inferred from NatureServe, 2015)

Redundancy:
Low (inferred from NatureServe, 2015)

Population Growth Rate:
Declining (inferred from NatureServe, 2015)

Number of Populations:
1 to 5 (inferred from NatureServe, 2015)

Population Size:
1 - 1000 (inferred from NatureServe, 2015)

Adaptability:
Low (inferred from NatureServe, 2015)

Population Narrative:
NatureServe (2015) notes that both long-term and short term population trends are decreasing. In addition NatureServe notes that there are 1 - 5 populations and that populations are estimated at between 1 and 1000 individuals. Resiliency, redundancy, representation and adaptability are inferred based on limited distribution and specific habitat needs as well as taxonomy (inferred from NatureServe, 2015).

Threats and Stressors

Stressor: Impoundments (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Dams change such areas by eliminating or reducing currents, and allowing sediments to accumulate on inundated channel habitats. Impounded waters also experience changes in water chemistry which could affect survival or reproduction of riverine snails. For example, many reservoirs in the Basin currently experience eutrophic (enrichment of a water body with nutrients) conditions and chronically low dissolved oxygen levels (Alabama Department of Environmental Management [ADEM], 1994, 1996). Such physical and chemical changes can affect feeding, respiration, and reproduction of these riffle and shoal snail species. In addition to directly altering snail habitats, dams and their impounded waters also formed barriers to the movement of snails that continued to live below dams or in unimpounded tributaries. It is suspected that many such isolated colonies gradually disappear as a result of local water and habitat quality changes. Unable to emigrate (move out of the area), the isolated snail populations are vulnerable to local discharges as well as any detrimental land surface runoff within their

watersheds. Although many watershed impacts have been temporary, eventually improving or even disappearing with the advent of new technology, management practices, or laws, dams and their impounded waters prevent natural recolonization by snail populations surviving elsewhere (USFWS, 2005).

Stressor: Water pollution (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Short-term and long-term impacts of point and nonpoint source water and habitat gradation continue to be a primary concern for the survival of all these snails, compounded by their isolation and localization. Point source discharges and land surface runoff (nonpoint pollution) can cause nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that are likely to seriously impact aquatic snails. Point sources of water quality degradation include municipal and industrial effluents. Nonpoint source pollution from land surface runoff can originate from virtually all land use activities, and may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and oils and greases (ADEM, 1996). During recent surveys for these snails, sediment deposition and/or dense algal mats (a sign of nutrient pollution of streams) were noted at many historic collection localities where snails had disappeared (Bogan and Pierson, 1993a, 1993b; Hartfield, 1991; Service Field Observations, 1992-1994, Jackson Field Office, MS) (USFWS, 2005).

Stressor: Sedimentation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Excessive sediments are believed to impact riverine snails requiring clean, hard shoal stream and river bottoms, by making the habitat unsuitable for feeding or reproduction. Similar impacts resulting from sediments have been noted for many other components of aquatic communities. For example, sediments have been shown to abrade and/or suffocate periphyton (organisms attached to underwater surfaces, upon which snails may feed); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters, 1995). Sediment is the most abundant pollutant produced in the Basin (ADEM, 1989). Potential sediment sources within a watershed include virtually all activities that disturb the land surface, and all localities currently occupied by these snails are affected to varying degrees by sedimentation. The amount and impact of sedimentation on snail habitats may be locally correlated with the land use practice, and the degree of implementation of agriculture, forestry, and construction Best Management Practices (USFWS, 2005).

Stressor: Runoff (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Land surface runoff contributes the majority of nutrients to streams in the Mobile River Basin (Atkins et al., 2004). Excessive nutrient input (from fertilizers, sewage waste, animal manure, etc.) can result in periodic low dissolved oxygen levels that are detrimental to aquatic

species (Hynes, 1970). Nutrients also promote heavy algal growth that may cover and eliminate clean rock or gravel habitats of shoal dwelling snails. Nutrient and sediment pollution may have synergistic effects (a condition in which the toxic effect of two or more pollutants is much greater than the sum of the effects of the pollutants when operating individually) on freshwater snails and their habitats, as has been suggested for aquatic insects (Waters, 1995) (USFWS, 2005).

Stressor: Waste water treatment (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: The cylindrical lioplax, flat pebblesnail, and the round rocksnail currently survive in localized reaches of the Cahaba River drainage. Water quality studies in the upper Cahaba River drainage by the Geological Survey of Alabama (Shepard et al., 1996) found that discharges from 34 waste water treatment plants (WWTPs) in the upper drainage have contributed to water quality impairment. This was reflected by low levels of dissolved oxygen downstream of Birmingham; ammonia and chlorination by-products in excess of recommended water quality criteria; and eutrophication (demonstrated by dense algal mats and nightly sags in dissolved oxygen levels) due to excessive levels of phosphorus and nitrogen. The study noted that these problems are chronic and have been a factor in a loss of mollusk and fish diversity throughout the drainage. Their results indicate that the upper Cahaba River drainage is primarily impacted by nonpoint runoff and WWTPs through physical habitat destruction by sedimentation, and chronic stress from exposure to toxics and low dissolved oxygen. The middle Cahaba River is primarily impacted by eutrophication and associated effects (USFWS, 2005).

Stressor: Predation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Aquatic snails are consumed by various vertebrate predators, including fishes, mammals, and possibly birds. Predation by naturally occurring predators is a normal aspect of the population dynamics of a species and is not considered a threat to these species. However, the potential now exists for black carp (Mylopharyngodon piceus), a nonselective snail eating fish recently introduced into waters of the United States, to eventually enter the Mobile River Basin. Exotic black carp escaped to the Osage River in Missouri when hatchery ponds were flooded during a 1994 spring flood of the river (LMRCC newsletter, 1994). Although black carp have been banned for use in aquaculture in the State of Alabama, they are cultured and sold within the State of Mississippi (D. Reike, Mississippi Department of Wildlife, Fisheries, and Parks, pers. comm., 1997). The extent of stocking black carp for snail control in aquaculture ponds within the Basin is currently unknown (USFWS, 2005).

Recovery

Delisting Criteria:
1. A minimum of 3 natural or re-established populations have been shown to be persistent (i.e., stable or increasing) for a period of 10 years (2 to 5 generations) (USFWS, 2005).

2. There are no apparent or immediate threats to the populations (see Listing/Recovery Factor Criteria, below). A population is defined as all snails occurring within a contiguous river or

stream reach extending a minimum of 30 km (18 mi). Snails in a recovered population should be easily found in appropriate habitat throughout the occupied reach (USFWS, 2005).

Recovery Actions:

- The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin. The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin (USFWS, 2005).
- 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control. 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches

currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control (USFWS, 2005).

- 2. Consider options for free-flowing river and stream mitigation strategies that give high priority to avoidance and restoration. As noted above, avoidance of impact is the most important and immediate management need for maintaining existing imperiled populations and their habitats. However, long-term management requires the ability to accommodate changes in human use of the Basin's resources. Restoration of stream and river reaches, and rehabilitation of their aquatic communities will increase management options to accommodate future changes within the Basin. Compensating for aquatic habitat impacts can be an important component of aquatic habitat management. 2.l Identify appropriate mitigation measures for free flowing streams and rivers. When destruction or alteration of stream or river habitat is unavoidable, there should be an effort to restore or rehabilitate a comparable amount of instream aquatic habitat elsewhere in the Basin. Unfortunately, there is little guidance or consensus for the amount and degree of measures that could satisfy mitigation goals for free flowing riverine habitat. Federal, State, and local environmental and regulatory agencies and nongovernmental interests must work toward consensus on this problem, considering issues such as amount, quality, and location of river or stream segments under consideration for mitigation measures, and other alternatives, such as the need and possibility of establishing mitigation banks for permit applicants. 2.11 Investigate the potential of partnerships and assistance to relieve land use problems within watersheds as a form of mitigation. Concentrated land uses within watersheds can overwhelm the benefits of individual landowner Best Management Practices (BMPs). Animal wastes from concentrated husbandry of poultry, fish, and livestock is a major determinant of water quality in some watersheds. Urbanization of watersheds also causes complex runoff/water quality problems. Such problem areas may offer creative mitigation opportunities. Examples include developing equipment, facilities, or other components to establish centralized waste treatment for areas of high concentration of poultry farms and other animal feedlots; and providing assistance to communities for stormwater catchment and treatment (USFWS, 2005).

- 3. Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use. BMPs can be effective and practical actions identified to prevent or reduce nonpoint pollution from specific land use activities (ADEM, 1989). For example, agricultural BMPs are designed to reduce sediments, animal wastes, fertilizers, and pesticides in stormwater runoff (e.g., Alabama Soil and Water Conservation Committee (ASWCC), 1995). Mining BMPs address sediments and water quality parameters such as acidity and metal concentrations (e.g., ADEM, 1989). Silviculture BMPs include actions to minimize sediments, nutrients, organics, chemicals, and stream canopy removal (e.g., Alabama Forestry Commission, 1993). BMPs are also available for urban, construction, and homeowner activities that address stormwater runoff quality and quantity (ASWCC, 1992, MSDEQ, 1994). BMPs are developed by State and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and State resource agencies should continue to promote and improve BMPs when necessary as a nonregulatory approach to aquatic ecosystem management. 3.1 Work with State and private partners to promote land and water stewardship awareness. Local offices of State and Federal agencies and private organizations can become a primary source of encouragement and information for imperiled species and aquatic ecosystem management. For example, local offices (e.g, Soil and Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commissions, private industry groups, environmental groups, etc.) can identify watersheds with listed species within their areas; inform local landowners of listed species' presence, needs, and special management concerns; recommend appropriate BMPs; and mediate landowner concerns or conflicts with appropriate State and/or Federal agencies. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity. Private industry groups can work with local landowners to customize BMPs where needed to address watershed problems and practices. 3.2 Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers in the Basin. Properly designed SMZs, which act as filter strips, can buffer the impacts of land use activities on water and stream bottom habitat quality. SMZs protect public and private property from erosion, reduce downstream sedimentation, and enhance fish and wildlife values for both game and nongame species. SMZs can also reduce nutrient levels in tributary streams in the Basin, which will help control eutrophication in Basin reservoirs (see Part I, Section C in Ecosystem Recovery Plan). Some farmlands adjacent to streams and rivers may qualify for SMZ set aside under the U.S. Department of Agriculture's Conservation Reserve Program and other initiatives. SMZs are widely recognized as cost effective habitat management practices. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. SMZs may be custom designed to protect stream habitat while achieving individual landowners management objectives. For example, the Natural Resources Conservation Service recommends SMZs from 22 to 91 meters (75 to 300 feet), with varying restrictions, depending on soil, slope, topography, and land use. Other government agencies and private groups make similar recommendations. SMZs are also effective in controlling urban and suburban stormwater runoff (USFWS, 2005).

- 4. Encourage and support community based watershed stewardship planning and action. Protection, restoration, and management planning for imperiled aquatic habitats is best accomplished by partners and stakeholders within a watershed. Such grassroots community planning educates participants about aquatic species, their habitat needs, and sensitivities; acknowledges local activities, problems and their effects on water; and leads to consensus based local solutions. Stewardship partnerships are essential in watersheds supporting listed or other imperiled aquatic species, and should be encouraged within any of the Basin's watersheds. Resource and regulatory agencies should offer support, materials, and technical and facilitation assistance when requested. 4.1 Reduce private land use/endangered species conflicts. Landowners and other watershed residents may feel threatened by the presence of listed aquatic species, and be reluctant to participate in watershed stewardship planning or action. In such cases, Watershed Habitat Conservation Plans, Safe Harbor Agreements, or other innovative avenues to assure and guarantee private land uses within watersheds should be developed (USFWS, 2005).
- 5. Develop and implement programs to educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship. Only an informed and proactive public can bring about ecosystem stabilization and rehabilitation. Successful ecosystem management will require public involvement, monitoring, and commitment of resources. Educational materials and programs should describe the concept and need for ecosystem management, its long-term economic and environmental advantages, and public and individual stewardship responsibilities (USFWS, 2005).
- 6. Conduct basic research on endemic aquatic species and apply the results toward management and protection of aquatic communities. The biology and ecology of endemic aquatic species in the Basin are poorly known. Information on distribution, habitat requirements, life stage sensitivity to contaminants, and the identification of mussel host fish is essential to the recovery of endemic species and management and protection of their communities and habitats. All partners should be aware of research efforts and results, so that information can be immediately applied. 6.1 Survey and monitor the status of listed and other endemic aquatic species. Extant populations of listed and other endemic species should be located and their status monitored. 6.2 Conduct detailed physical and molecular genetic analyses of endemic species. Most of the Basin's endemic aquatic species have not been fully described anatomically. This information, in conjunction with genetic biochemical comparisons of populations and related species, may provide information important to population management and recovery. 6.3 Determine contaminant sensitivity for each life stage. It is known that juvenile and adult life stages of aquatic fauna may differ in sensitivity to contaminants. The technology and methodology should be developed to determine sub-lethal and lethal levels of pesticides, herbicides, and common contaminants and discharges to listed species and other endemic organisms in the Basin. 6.4 Conduct life history research on endemic species to include reproduction, food habits, age and growth, mortality factors. etc. Life history information may provide insight into past declines, current status of endemic species, weak links in the life cycle, and management guidance for their recovery. 6.41 Determine nutritional requirements of endemic species life stages. It is possible that juvenile forms of many taxa feed on different items than adults. Such requirements may be limiting factors in the survival of these species. Nutritional requirements must be known for successful captive propagation of endemic species (see Task 7) (USFWS, 2005).
- 7. Develop and implement technology for maintaining and propagating endemic species in captivity. Populations of endemic species in the Basin are isolated by large expanses of

impounded, or otherwise severely altered, habitat. Maintenance of genetic flow between extant populations, and reintroduction of species to restored habitats, will require human intervention. Populations of many species are currently too low to justify translocation of wild stock between drainages. Captive propagation will be required to produce reintroduction stock if ecosystem restoration is eventually successful (see Task 8). Large numbers of juveniles and adults will also be needed for research to determine sensitivity of species to common contaminants (Task 6.3) (USFWS, 2005).

- 8. Reintroduce aquatic species into restored habitats, as appropriate. For many listed species, this step will be possible only when, and if, successful captive propagation technology is developed. Reintroduction will be closely coordinated with appropriate State agencies and affected private landowners. No reintroduction or translocation of species should be made without the concurrence of the appropriate State wildlife resource agencies and the knowledge and consensus of local watershed residents. 8.1 Identify sites for translocation/reintroduction. Potential sites for reintroduction consist of streams within the historic range of endemic species that meet the substrate, flow, water quality, and other environmental requirements of the species. Such sites need to be identified and monitored. 8.11 Survey and prioritize potential sites. Water quality, substrate composition, aquatic community composition, and watershed land uses should be characterized. Priority should be given to watersheds with appropriate habitat, diverse faunal assemblages, minimal land use impacts, and active management programs. 8.2 Translocate target endemic species to priority sites. Translocations should be conducted in a rigorous, scientific manner, and should be well-documented. 8.3 Monitor translocated populations. Stream and river reaches with translocated populations should be monitored and surveyed annually for a minimum of 10 years following translocation (USFWS, 2005).
- 9. Monitor listed species population levels and distribution and periodically review ecosystem management strategy. Listed species will be monitored by Tasks 6.1 and 8.3. Changes in distribution (losses and gains) should be used to focus recovery efforts and priorities. Ecosystem management strategy should be periodically reviewed and revised, if appropriate, based on this information (USFWS, 2005).
- 10. Coordinate ecosystem management actions. The above recovery tasks approach ecosystem stabilization and management on three tiers: Federal and State regulatory authority and responsibility; private activities, public education and involvement; and research. Implementation of these tasks will involve multiple partners including State and Federal agencies, municipal and county governments, environmental and recreational organizations, civic groups, educational and research institutions, business and industry groups, landowners, and interested individuals. Successful implementation requires development of partnerships, coordination of on-going activities, determination and prioritization of needed actions, and monitoring recovery progress within each of the Basin's major drainages (USFWS, 2005).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS: • Conduct systematic population monitoring of extant and reintroduced populations of these snails and document potential threats to those populations. • Evaluate the status of the lacy elimia in Emauhee and Weewoka Creeks and confirm that its status in Cheaha Creek remains stable. Also conduct surveys within the Middle Coosa River tributaries that are within the historic range of the species. Results from these studies may suggest a need to upgrade its ESA status from threatened to endangered. • Continue to evaluate the extent and viability of the new populations of cylindrical lioplax within the Little Cahaba River, Yellowleaf Creek, and Choccolocco Creek, in order to determine if it meets the recovery criteria for downlisting to threatened. • Reassess and amend as needed the recovery plan for 6 Mobile River Basin aquatic snails, specifically, the recovery criteria and population criteria for recovery should be evaluated. • Continue to develop and implement habitat restoration plans for the streams where these species occur, or where they can be reintroduced. • Continue assisting the State's propagation studies and efforts. • Work with State agencies, local groups, and individuals to protect and improve water quality in the drainages supporting the six snail species. • Implement all other recovery tasks (USFWS, 2016).

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USFWS. 2016. Cylindrical Lioplax (Lioplax cyclostomaformis) Flat Pebblesnail (Lepyrium showalteri) Plicate Rocksnail (Leptoxis plicata) Painted Rocksnail (Leptoxis taeniata) Round Rocksnail (Leptoxis ampla) Lacy Elimia (Elimia crenatella) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office.

SPECIES ACCOUNT: *Erinna newcombi* (Newcomb's snail)

Species Taxonomic and Listing Information

Listing Status: Threatened; 01/26/2000; Pacific Region (R1) (USFWS, 2016)

Physical Description

A small freshwater snail with a smooth black shell. The characteristic spire that is found on other freshwater snails in Hawaii is absent.A small freshwater snail with a thin, brownish, almost spireless shell. (NatureServe, 2015)

Taxonomy

At the present time, no completely accepted nomenclature exists for the genera of Hawaiian lymnaeids, although each of these snail species, including Newcomb's snail, is recognized as a valid species. Hubendick (1952) did not believe the distinctive shell form (described above) and reduced structures of the nervous system of Newcomb's snail warranted a monotypic genus. In fact, Hubendick included all Hawaiian lymnaeids in the genus Lymnaea. Morrison (1968) contradicted Hubendick and argued the distinctive shell characters of Newcomb's snail supported the generic name Erinna. Burch (1968), Patterson and Burch (1978), Taylor (1988), and Cowie et al. (1995) all followed Morrison and referred to Newcomb's snail as Erinna newcombi, which is the currently accepted scientific name (USFWS, 2006).

Historical Range

See current range/distribution

Current Range

The total known range, historic and present, is only nine streams on the island of Kauai (Cowie et al., 1995; Hubendick, 1951; 1952), with six of these currently harboring snails, and only two harboring large numbers of individuals.

Critical Habitat Designated

Yes; 8/20/2002.

Legal Description

On August 20, 2002, the U.S. Fish and Wildlife Service (Service) designated critical habitat for the Newcomb’s snail (Erinna newcombi) pursuant to the Endangered Species Act of 1973, as amended (Act). The designated critical habitat consists of eight stream segments and associated tributaries, springs and seeps, and adjacent riparian areas on the island of Kauai, Hawaii, totaling 19.76 kilometers (12.28 miles) of stream channel and 1,812 hectares (4,479 acres).

Critical Habitat Designation

Areas designated as critical habitat for the Newcomb’s snail occur in eight separate streams and include the main channel of a named stream, contiguous named and unnamed tributaries, and adjacent springs and seeps, and associated riparian areas. Critical habitat includes sub-units under State and private ownership and includes six sites currently known to be occupied (Kalalau Stream, Lumahai River, Hanalei River, Waipahee stream, Makaleha Stream, and North Fork Wailua River) and, in addition, includes two sub-units where the species was known to occur in the early 1900s, but where it is now thought to be extirpated (Hanakoa and Hanakapiai Streams).

Unit I: Na Pali Coast Streams. Streams in the Na Pali Coast unit are small, short, and flow over steep terrain. These streams are located in the northwest quadrant of the island, and, because they are located in smaller watersheds, they are directly exposed to coastal weather conditions. Rainfall in this area is lower than in the other watersheds designated as critical habitat. The vegetation of the Na Pali Coast Stream Unit consists primarily of mixed-species mesic (moderate moisture) forest composed of native and introduced plant species. The higher elevations are primarily native forest, but the lower elevations are more disturbed and are dominated by introduced plant species. Newcomb's snail is known from three stream subunits in this unit, Kalalau Stream, Hanakoa Stream, and Hanakapiai Stream. Kalalau Stream is currently occupied. Hanakoa Stream and Hanakapiai Stream were known to harbor Newcomb's snail populations relatively recently but the species is now thought to be extirpated at those sites. Sub-Unit I(a): Kalalau Stream. Critical habitat for Newcomb's snail is designated for all flowing waters associated with the east fork of Kalalau Stream and its tributaries, including springs and seeps, and riparian habitat necessary to maintain the integrity of the watershed. The Kalalau Stream location designated includes 1.38 km (0.86 mi) of stream channel and 149 ha (368 ac) and lies within the elevational contours of 183 to 488 m (600 to 1,600 ft). This reach contains one of the two largest known populations of Newcomb's snails, and it contains the largest observed population of snails documented on public lands. At least two large, vertical or overhanging waterfalls in this reach appear to provide important refuge from high, channel-scouring flows (S. Miller, in litt. 1994b). This population is currently the most isolated of the known Newcomb's snail populations, and it is separated from the nearest neighboring population, located in Lumahai River, by 11.8 km (7.3 mi). It is the only remaining population in the northwest quadrant of the island. This sub-unit is essential to the conservation of Newcomb's snail because it has the most robust population of snails ever recorded, as documented in a Service survey conducted in 1994. This sub-unit is required to maintain one of the six known populations of snails. This stream segment is located within the Na Pali Coast State Park. Kalalau Stream has no water diversions. Sub-Unit I(b): Hanakoa Stream. Critical habitat for Newcomb's snail is designated for all flowing waters associated with Hanakoa Stream and its tributaries, including springs and seeps and riparian habitat necessary to maintain the integrity of the watershed. The Hanakoa Stream location designated includes 0.80 km (0.50 mi) of stream channel and 63 ha (156 ac) and falls within the elevational contours of 122 to 457 m (400 to 1,500 ft). Historical records from the early 1900s indicate that Newcomb's snails were found in this stream; however, a recent survey failed to locate any snails (S. Miller in litt. 1994b). This reach is located on the northwest side of the island and is exposed to severe weather approaching from the northwest. Hanakoa Stream was heavily impacted by Hurricane Iniki in 1992 (Fitzsimons et al. 1993), prior to surveys intended to locate populations of Newcomb's snail. This sub-unit is essential to the conservation of Newcomb's snail because the currently known occupied sub-units are not sufficient to provide for the long term conservation of the species alone. The sub-units currently known to be occupied by Newcomb's snail populations are not sufficiently dispersed to consider the species safe from extinction. Existing known populations are found in remarkably small areas of only a few square meters of aquatic habitat, each of which is at risk from even a small, localized landslide or high flow event. Hanakoa Stream also adds to the geographic diversity by adding areas in the northwest quadrant of the island which is likely to be most exposed to severe weather events such as hurricanes from the north and northwest. Currently, the only known occupied site in this quadrant is Kalalau Stream. With the exception of the Kalalau Stream population, all other populations of Newcomb's snails are located in the northeast or southeast quadrants of the island, and these sites would be exposed to severe weather events such as hurricanes primarily from the northeast and east. This location on Hanakapiai stream is within the historical range of Newcomb's snail, is well documented in museum and other historical records, and was most recently known to be occupied compared to other streams (the early 1900's as opposed to Hanapepe Stream where specimens were collected in the 1840's with no additional information available). Additionally, this stream segment is located within the Na Pali Coast State Park and is adjacent to the Honu O Na Pali Natural Area Reserve and has no water diversions which make it less likely to have land use conflicts. Sub-Unit I(c): Hanakapiai Stream. Critical habitat for Newcomb's snail is designated for all flowing waters associated with Hanakapiai Stream and its tributaries, including springs and seeps, and riparian habitat necessary to maintain the integrity of the watershed. The Hanakapiai Stream location designated includes 0.56 km (0.35 mi) of stream channel and 35 ha (86 ac) and falls within the elevational contours of 183 to 457 m (600 to 1,500 ft). Historical records indicate that Newcomb's snail occurred in this reach; however, no recent surveys have located snails (M. Kido, in litt. 1994; G. Smith, pers. obs. 2002). This reach, like those in Kalalau and Hanakoa streams, is located in the northwest portion of the island and is exposed to severe weather from the north and northwest (Fitzsimons et al. 1993). This sub-unit is essential to the conservation of Newcomb's snail because currently occupied sub-units and the addition of one other unoccupied stream is not sufficiently dispersed to consider the species safe from extinction. As with sub-unit I(b), the addition of Hanakapiai Stream will provide section 7 protections for additional habitat necessary to reestablish the snail in additional streams in this part of the island and once the snails are reestablished, will decrease the risk of losing the presence of snails in the northwest quadrant of the island. Streams in the northwest quadrant of the island are likely to be most exposed to severe weather events such as hurricanes from the north and northwest and currently only contains one occupied location in Kalalau Stream. The five other known occupied stream sub-units are located in the northeast or southeast quadrants of the island, and these sites would be exposed to severe weather events such as hurricanes primarily from the northeast and east. This location on Hanakoa stream is within the historical range of Newcomb's snail, is well documented in museum and other historical records, and was most recently known to be occupied compared to other streams (the early 1900's as opposed to Hanapepe Stream where specimens were collected in the 1840's with no additional information available). In addition, this stream segment is located within the Na Pali Coast State Park and is adjacent to the Honu O Na Pali Natural Area Reserve and has no water diversions, making it less likely to have conflicting land uses.

Unit II: Central Rivers. The central rivers of Kauai are large relative to other streams in the State, and flow through relatively low-gradient watersheds. These rivers are located in the northern half of the island and, because their headwaters are located well inland and in large valleys, are exposed to weather conditions that are greatly influenced by the surrounding landmass. Rainfall in this area is higher than in the other watersheds designated as critical habitat. The vegetation of the Central Rivers Complex watersheds consists primarily of mixed-species wet and mesic forest composed of native and introduced plant species. The higher elevations are primarily native forest, but the lower elevations are more disturbed and are dominated by introduced plant species. The two subunits, Lumahai River and Hanalei River are occupied by Newcomb's snail. Sub-Unit II(a): Lumahai River. Critical habitat for Newcomb's snail is designated for all flowing waters associated with Lumahai River and its tributaries, including springs and seeps, and riparian habitat necessary to maintain the integrity of the watershed. The Lumahai River location designated includes 5.0 km (3.11 mi) of stream channel and 492 ha (1,216 ac) and falls within the elevational contours of 183 to 457 m (600 to 1,500 ft). One of the largest populations of Newcomb's snails ever documented occurs in this reach of Lumahai River and its tributaries. This stream segment is located on private land. Lumahai River has no water diversions. This sub-unit is essential to the conservation of Newcomb's snail because it has one of the most robust population of snails ever discovered, as recorded at the time of the discovery of the population by Hawaii Department of Land and Natural Resources division of Aquatic Resources personnel in 1994. This sub-unit is required as critical habitat to conserve one of the six known populations of Newcomb's snails. Sub-Unit II(b): Hanalei River. Critical habitat for Newcomb's snail is designated for all flowing waters associated with the Hanalei River and its tributaries, including springs and seeps, and riparian habitat necessary to maintain the integrity of the watershed. The Hanalei River location designated includes 7.58 km (4.71 mi) of stream channel and 876 ha (2,165 ac) and falls within the elevational contours of 122 to 457 m (400 to 1,500 ft), excluding ditches and flumes. The four subpopulations found within this stream system represent the largest number of Newcomb's snail sub-populations occurring within a single watershed. Segments of several named tributaries to the Hanalei River are included in this designation, and these include Kaapoko, Kaiwa, and Waipunaea Streams. This stream segment is located within the Halela Forest Reserve on State lands. The critical habitat that contains the Hanalei River subpopulations of Newcomb's snail is essential to the conservation of the species because this area is needed to maintain one of the six existing known populations of snails. A complex of stream diversion works that includes dams, ditches and tunnels, is found at the 378 m (1,240 ft) elevation of the Hanalei River, in the vicinity of the upper two main-channel Hanalei River sub-populations and upstream of the Kaapoko tributary sub-population at an elevation of 396 m (1,300 ft). These dams and associated ditches and tunnels historically diverted large volumes of water out of Kaapoko tributary and the Hanalei River to watersheds in the southeast portion of the island for irrigation use. Typical diversion structures in Hawaiian streams completely divert all of a stream's flowing water during moderateto low-flow periods, leaving the stream channel below the dam completely dry. The water diversion structures and associated ditches and tunnels in the upper Hanalei River and its tributaries have been in disrepair since the early 1990s. Although these human-made features locally alter flow characteristics, no water is currently diverted out of the Hanalei watershed.

Unit III: Eastside Mountain Streams. The streams designated as critical habitat in this area flow towards the east and southeast portions of the island and are intermediate in size. Rainfall is moderate in comparison to the other sub-units designated as critical habitat. All three of the sub-units included in this stream complex, Waipahee Stream, Makaleha Stream, and North Fork Wailua River, are occupied by populations of snails. The vegetation of the Eastside Mountain Stream watersheds consists primarily of mixedspecies wet forest composed of native and introduced plant species. The higher elevations are primarily native forest, but the lower elevations are more disturbed and are dominated by introduced plant species. Sub-Unit III(a): Waipahee Stream. (Tributary to Kealia Stream) Critical habitat for Newcomb's snail is designated for all flowing waters associated with Waipahee Stream and its tributaries, including springs and seeps, and riparian habitat necessary to maintain the integrity of the watershed. The Waipahee Stream location in the proposed rule included 2.41 km (1.50 mi) of stream channel and 106 ha (262 ac). Due to new information received during the comment period, indicating that some of the area originally proposed does not contain the primary constituent element of perennial flow, we reduced the size of this designation by 0.68 km (0.43 mi) of stream channel and 40 ha (99 ac). The Waipahee Stream location designated now includes 1.73 km (1.08 mi) of stream channel and 66 ha (163 ac) and falls within the elevational contours of 262 to 366 m (680 to 1,200 ft). Newcomb's snail was historically known to occur in Waipahee Stream, and a survey has confirmed the presence of Newcomb's snails within this reach (A. Asquith, in litt. 1994a). The location designated on Waipahee Stream is occupied by Newcomb's snail and is essential to the conservation of the species because this area is needed to maintain one of the six existing populations of snails. Waipahee Stream is located on private land that, in areas below the 262 m (680 ft) elevation and outside of designated critical habitat, is undergoing a transition in use from commercial plantation-style sugarcane agriculture to pasture, forestry, diversified crops, and ''ecotourism'' use. Higher elevation areas (above the 262 m (680 ft) elevation) of these private lands, such as where Newcomb's snails are found, are not used for agriculture and are relatively undisturbed. Water is diverted from Kealia Stream at several locations at lower elevations (below the 262 m (680 ft) elevation) outside of the designated critical habitat location. Sub-Unit III(b): Makaleha Stream (Tributary to Kapaa Stream) Critical habitat for Newcomb's snail is designated for all flowing waters associated with Makaleha Stream and its tributaries, including Makaleha Springs, other springs, and seeps, and riparian habitat necessary to maintain the integrity of the watershed. The Makaleha Stream location designated includes 1.59 km (0.99 mi) of stream channel and 95 ha (235 ac) and falls within the elevational contours of 183 to 457 m (600 to 1,500 ft). The Makaleha Stream and Makaleha Springs Newcomb's snail populations have been surveyed several times in recent years. Two subpopulations are known to occur within this reach. Newcomb's snails are found within the complex of small tributary streams originating from Makaleha Springs, and a small number of snails are found upstream of the springs at a waterfall located in the Makaleha Stream main channel. This stream segment is located within the Kealia Forest Reserve on State lands. The critical habitat that contains the Makaleha Stream population of Newcomb's snail is essential to the conservation of the species because this area is needed to maintain one of the six existing populations of snails. Water is diverted from Makaleha Stream and Kapaa Stream at several locations at lower elevations (below 183 m (600 ft) elevation) and outside of designated critical habitat locations. Sub-Unit III(c): North Fork Wailua River. Critical habitat for Newcomb's snail is designated for all flowing waters associated with the North Fork of the Wailua River and its tributaries, including springs and seeps, and riparian habitat necessary to maintain the integrity of the watershed. The North Fork Wailua location in the proposed rule included 1.71 km (1.06 mi) of stream channel and 64 ha (158 ac). Due to new information received during the comment period indicating that some of the area we proposed did not contain the primary constituent element of perennial flow, we reduced this designation by 0.59 km (0.37 mi) of stream channel and 28 ha (68 ac). The North Fork Wailua River location designated now includes 1.12 km (0.7 mi) of stream channel and 36 ha (90 ac) and falls within the elevational contours of 335 to 427 m (1,100 to 1,400 ft). This population was discovered in 1995 and has fluctuated in size in subsequent observations (A. Asquith, in litt. 1995). This stream segment is located within the Lihue-Koloa Forest Reserve on State lands. A water diversion exists just downstream of the critical habitat boundary. The location designated as critical habitat in the North Fork Wailua River is occupied by Newcomb's snail and is essential to the conservation of the species because this area is needed to maintain one of the six known populations of snails.

Primary Constituent Elements/Physical or Biological Features

Critical Habitat Units are designated for the County of Kauai, Hawaii. Within these areas, the primary constituent elements required by the Newcomb's snail are those habitat components that are essential for the biological needs of foraging, sheltering, reproduction, and dispersal. The primary constituent elements are:

(i) cool, clean, moderate-to fast-flowing water in streams, springs, and seeps;

(ii) their adjacent riparian areas and hydrogeologic features that capture and direct water flow to these spring and stream systems;

(iii) a perennial flow of water throughout even the most severe drought conditions; and

(iv) stream channel morphology that provides protection from channel scour by having overhanging waterfalls, protected tributaries, or similar refugia.

Special Management Considerations or Protections

Existing human-made features and structures within the boundaries of the mapped units, such as dams, ditches, tunnels, flumes, and other human-made features that do not contain the primary constituent elements, are not included as critical habitat.

Life History

Feeding Narrative

Adult: Feed on algae and vegetation growing on submerged rocks (FWS, 2004).; Food Habits: Herbivore (Adult) (NatureServe, 2015)

Reproduction Narrative

Adult: Newcomb's snail is an obligate freshwater species. The details of its ecology, such as life span, reproductive cycle, and number of eggs/young, are unknown (USFWS, 2006). Eggs are attached to submerged rocks or vegetation and there are no widely dispersing larval stages; entire life cycle tied to stream system (FWS, 2004).; (NatureServe, 2015)

Environmental Specificity

Adult: Very narrow. Specialist or community with key requirements scarce. (Natureserve, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Inhabits fast-flowing perennial streams on the island of Kauai. Habitat is limited to areas that are not scoured during heavy rains, such as rock seeps, and waterfalls. Water source consistent and permanent (USFWS, 2004; 2006). It is only found in areas protected from high scouring flows within main stream channels (USFWS, 2006). Benthic (NatureServe, 2015). Clumped spatial arrangements of the population, high ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the specific habitat requirements of the species (including apparent elevation restrictions) and the relatively low number of known populations. Limited to a relatively narrow zone of mid-elevation sites, populations of Newcomb=s snail are found at an average elevation of 306 meters (1,005 feet), and range between 196 meters and 396 meters (643 feet to 1,299 feet) (USFWS, 2006).

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 2006)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2006)

Dispersal

Adult: Low (USFWS, 2006)

Immigration/Emigration

Adult: Unlikely (USFWS, 2006)

Dispersal/Migration Narrative

Adult: Dispersal of snails in both upstream and downstream directions within a stream system probably plays an important function in gene flow and in colonizing or recolonizing suitable habitat, particularly microhabitat that is protected from channel scour. Dispersal of Newcomb's snail between stream systems is likely very infrequent due to their obligate freshwater habitat requirements, and historic dispersal probably relied on long-term erosional events that captured adjacent stream systems (FWS, 2004). (NatureServe, 2015). Snails attach eggs to submerged rocks or vegetation and larval stages do not disperse widely; the entire life cycle is tied to the stream system in which the adults live (Baker 1911) (USFWS, 2006).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (inferred from NatureServe, 2015)

Representation:

Low (inferred from NatureServe, 2015)

Redundancy:

Low (inferred from NatureServe, 2015)

Population Growth Rate:

Decline of 70-90% (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

2500 - 10,000 individuals (NatureServe, 2015)

Population Narrative:

Dramatic changes in watershed use, although not immediately imminent, as well as unpredictable catastrophic events could have major impacts. Very limited area of occurrence.

Decline of 70-90% High density (800/square meter) at Kalalau Stream; Lumaha'i River population size unknown; Hanalei River population has four subpopulations, one with 10-20/square meter (total 2-3 square meters only), one with 25 total snails, and two even smaller; Makaleha Stream has two subpopulations, one with 30/square meter (2-3 square meters total), and up to 20-30/square meter in another (20-30 square meters total); north fork of Wailua River has only a few scattered individuals. 6 known populations have total 6000 to 7000 individuals (90% in Kalalau and Lumaha'i (USFWS, 2004; 2006) Five populations were identified up to 1925 including Hanakapiai at head of valley near waterfall; overhangind rock in Hanakapiai Stream; Kalalau; near Halalu Falls in Hanakoa; valley above dam in Waipahi (Hubendick, 1952). Surveys of 46 streams, tributaries and springs between 1990 and 1995 have found four additional populations (Lumahai River, Makaleha Stream, Hanalei River, and north fork Wailua River), confirmed its continuing presence in two of the previously known localities, but its absence in three of them (USFWS, 2004). The known range is limited to small sites located in a total of six watersheds in north- and east-facing drainages on Kaua'i, with no interaction between subpopulations (USFWS, 2006). A population (7 individulas observed, but most likely much larger numbers exist) was recently rediscovered in Hanakoa Valley around the west side of the falls on Kaua'i, Hawaii; where it had historically been reported in July of 1907 (Boynton and Wood, 2007). (NatureServe, 2015). Low resiliency, representation and redundancy are based on the number of use sites and their relatively restricted geography as well as the overall population size.

Threats and Stressors

Stressor: Human-caused changes to the hydrologic landscape (USFWS, 2006)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The specific effects of surface water diversion or groundwater withdrawal on the Newcomb's snail are unknown. However, none of the six known snail populations are found below points of significant water diversion. Three of four Hanalei subpopulations are found in close proximity to, or below, sites once part of a major stream diversion complex now abandoned and nonfunctional. These subpopulations were not reported prior to this diversion complex falling into disuse, so effects on snails, other than possibly reducing snail abundance below the level of detection, are not known. A recent water development plan stands as an example of water withdrawal as a threat to Newcomb's snail. In 1995, prior to Newcomb's snail being listed as threatened, the County of Kaua`i planned a major water diversion project to capture flow from Makaleha Springs for domestic use. The project construction and operation was expected to eliminate the entire subpopulation of Newcomb's snail at Makaleha Springs. The application process was continued by the Kaua`i Board of Water Supply and cleared a number of State and local regulatory reviews. Ultimately, the State Commission on Water Resource Management denied the applicable permits on the basis of numerous unresolved environmental issues, including impacts to aquatic life (M. Wilson in litt. 1995) (USFWS, 2006).

Stressor: Predation (USFWS, 2006)
Exposure:
Response:
Consequence: Loss of individuals

Narrative: Predation by the non-native rosy glandina snail (Euglandina rosea) remains a serious threat to the survival of Newcomb's snail (U.S. Fish and Wildlife Service 2000). This predatory snail, introduced into Hawai`i in 1955 (Funasaki et al. 1988), has established populations throughout the main islands. The rosy glandina feeds on snails and slugs, and field studies document that it readily feeds on native snails found in Hawai`i (Hadfield et al. 1993). Furthermore, Kinzie (1992) demonstrated that the rosy glandina snail exhibits remarkable hunting behaviors leading to capture and predation of submerged prey. Although terrestrial, the rosy glandina will fully immerse itself in water to locate and feed on aquatic molluscs such as Newcomb's snail. The rosy glandina has been observed on the wet, algae-covered rocks of the Makaleha Stream in close proximity to individual Newcomb's snails (S. Miller in litt. 1994a), and is believed to prey on them. The rosy glandina snail is responsible for the extirpation of many populations and even the extinction of numerous species of native snails throughout the Pacific Islands (Tillier and Clarke 1983; Murray et al. 1988; Hopper and Smith 1992; Hadfield et al. 1993; Miller 1993), and represents a significant threat to the survival of Newcomb's snail. Predation on the eggs and adults of native Hawaiian lymnaeid snails by two non-native species of sciomyzid flies represents a significant threat to the survival of Newcomb's snail. Two species of marsh flies (Sepedomerus macropus and Sepedon aenescens) that feed on lymnaeid snails (Davis 1960) were introduced into Hawai`i in 1958 and 1966, respectively. Another widespread non-native aquatic insect group, the Trichoptera, (caddisflies), appears to be expanding its range throughout the Hawaiian Islands. In 2001, a fourth species was documented to occur in the islands (Flint et al. 2003). It is suspected that the introduced caddisflies are adversely impacting native aquatic invertebrate populations either through competition for space and resources, or due to the its large body size and sheer abundance in Hawaiian streams (Flint et al. 2003). Several introduced, predatory aquatic species, including the green swordtail fish (Xyphophorus helleri), the American bullfrog (Rana catesbiana), the wrinkled frog (Rana rugosa), and the cane toad (Bufo marinus) potentially threaten populations of Newcomb's snail (USFWS, 2006).

Stressor: Inadequacy of Existing Regulatory Mechanisms (USFWS, 2006)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: State regulatory mechanisms do not provide adequate protection for the Newcomb's snail's habitat. The State Water Code does not require permanent or minimum instream flow standards solely for the protection of aquatic wildlife. Existing Federal regulatory mechanisms that may protect the Newcomb's snail and its habitat are also inadequate (USFWS, 2006).

Stressor: Small populations (USFWS, 2006)
Exposure:
Response:
Consequence: Extinction
Narrative: Even if the threats responsible for the decline of this species were controlled, the persistence of existing populations is complicated by the small number of extant populations and the small geographic range of the known populations. This circumstance makes the species more vulnerable to extinction due to stochastic natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Center for Conservation Biology 1994). Small populations are also demographically vulnerable to extinction

caused by random fluctuations in population size and sex ratio, and to catastrophes such as hurricanes (Lande 1988) (USFWS, 2006).

Stressor: Altered hydrology
Exposure:
Response:
Consequence:
Narrative: Altered hydrology (USFWS 2000, 2006; Polhemus and Asquith 1996; P. Levin, pers. comm. 2011a,b) o Agricultural development and stream diversion loss of habitat o Dewatering aquifers loss of habitat o Vertical wells loss of habitat o Channelization loss or degradation of habitat o Hydroelectric power loss or degradation of habitat

Stressor: Landslides and flooding loss or degradation of habitat
Exposure:
Response:
Consequence:
Narrative: Landslides and flooding loss or degradation of habitat (Jones et al. 1984; Polhemus 1993; USFWS 2000, 2006)

Stressor: Stochastic events
Exposure:
Response:
Consequence:
Narrative: Stochastic events – Hurricane mortality and reduced viability (Polhemus 1993)

Recovery

Delisting Criteria:
The Newcomb's snail can be considered for delisting when: 1. Abundance and population variability are quantified, and populations (an unspecified number of individuals that allows for environmental, climatic, and genetic variations) are stable or increasing in size due to natural reproduction for a minimum of 5 consecutive years (population goals can not be quantified here, because little fieldwork has been completed on this species in the past 10 years, and original data on sites and densities were rough estimates based on casual observance and not surveys conducted according to a protocol) (USFWS, 2006).

2. Populations are identified in a minimum of eight watersheds with a wide geographical distribution throughout the range of the Newcomb's snail (USFWS, 2006).

3. Minimum in-stream flows protective of aquatic life are established and implemented for stream reaches containing Newcomb's snail populations (USFWS, 2006).

4. Non-native predators and competitors have been studied, their effects on the snail quantified, and the appropriate control measures have been established and implemented in order to support the population goal researched under criterion 1 above; and (USFWS, 2006).

5. A post-delisting monitoring plan has been developed (USFWS, 2006).

Recovery Actions:

- 1. Confirm populations are extant, determine baseline snail population numbers (USFWS, 2006).
- 2. Research the Newcomb's snail population biology and life history (USFWS, 2006).
- 3. Analyze and prevent predation and other forms of negative interspecific interactions that may limit or reduce Newcomb=s snail populations (USFWS, 2006).
- 4. Protect spring and instream flows that provide Newcomb=s snail habitat (USFWS, 2006).
- 5. Incorporate recovery of Newcomb=s snail into other landscape conservation efforts such as preservation of upland forests that maintain and regulate surface run-off to streams and act as areas of infiltration for groundwater (USFWS, 2006).
- 6. Use initial recovery efforts and research to periodically validate recovery objectives (USFWS, 2006).
- 7. Develop and implement a public outreach program for Newcomb=s snail conservation (USFWS, 2006).

Conservation Measures and Best Management Practices:

- Study factors that threaten the Newcomb's snail. This includes predation by introduced organisms such as the predatory snail Euglandina rosea, habitat degradation due to invasive aquatic and terrestrial species, and other biological and physical changes to their habitat (USFWS, 2009).
- Monitor snails at the Hanakapiai Stream to determine the cause of the snail's extirpation. The likely cause of the disappearance of the snails that were documented at that site historically is not known. The characterization of threats to the snails is important to inform recovery planning and implementation (USFWS, 2009).
- Revisit all locations where Newcomb's snails have been reported in the last 20 years and obtain quantitative population data. As time and resources allow, this survey program should be augmented to include visits to unsurveyed areas likely to harbor snails, and also revisiting of areas that historically had snails but where they are now thought to be extirpated (USFWS, 2009).
- Recommendations for Future Actions: No significant new information regarding the species biological status have come to light since the last 5-year review in 2009. Thus, the following recommendations for future actions are reiterated for 5-year review for 2016. • Population biology research – Conduct research and monitoring essential to the conservation of the species (USFWS 2006). • Predator / herbivore monitoring and control – Identify and manage predation (USFWS 2006) • Other threats monitoring and control – Identify and mange interspecific interaction (USFWS 2006). • Spring and instream flow protection – Maintain stream and spring flows to protect Newcomb's snail habitat (USFWS 2006). • Surveys / inventories – Revisit all locations where Newcomb's snails have been reported in the last 20 years and obtain quantitative population data. As time and resources allow, this survey program should be augmented to include visits to unsurveyed areas likely to harbor snails, and also revisiting of areas that historically had snails but where they are now thought to be extirpated. • Threats – predator / herbivore control research – Assess the predation threat by nonnative organisms such as the predatory snail Euglandina rosea. • Population viability monitoring – Monitor Hanakapiai Stream habitat to determine the cause of the snail's extirpation. The cause of the snail's disappearance that was documented at that site historically is not known. Identification of threats to the snails is important for informed recovery planning and implementation (USFWS, 2017).

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SPECIES ACCOUNT: *Eua zebrina* (No common name)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/24/2016; Pacific Region (R1) (USFWS, 2016a)

Physical Description

Eua zebrina varies in color ranging from almost white to pale-brown, to dark brown or purplish; with or without a zebra-like pattern of flecks and lines (Cowie and Cooke 1999, pp. 29–30). Most E. zebrina shells have transverse patterning (distinct coloration perpendicular to whorls). Shell length at birth is 0.12 to 0.14 inches (in) (3 to 3.5 millimeters (mm)) and sexual maturity is attained in less than one year at a shell length of 0.43 to 1.18 in (11 to 30 mm), depending on the species. (USFWS, 2014; USFWS, 2016b)

Taxonomy

The Tutuila tree snail is a member of the family Partulidae, which is widely distributed throughout the high islands of Polynesia, Melanesia and Micronesia in the south- and west-Pacific basin (Cowie 1992). Many of the 123 partulid species (Kondo 1968) are restricted to single islands or isolated groups of islands. The Samoan partulid tree snails are a good example of this endemism. Cowies 1998 taxonomic work is the most recent and accepted taxonomy for this species. (USFWS, 2014)

Historical Range

The Tutuila tree snail was historically known only from Tutuila. (USFWS, 2014)

Current Range

The Tutuila tree snail is found on the islands of Tutuila and Ofu (Cowie and Cook 2001) in American Samoa. (USFWS, 2014)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: This species presumably feeds primarily on senescent or decaying plant material like other partulid snails. (USFWS, 2014)

Reproduction Narrative

Adult: The biology of Samoan partulid tree snails has not been extensively studied. However, there is considerable information (reviewed by Cowie 1992) on the partulid tree snails of the Mariana Islands (Crampton 1925a; Hopper and Smith 1992) and the Society Islands (Crampton 1925b, 1932; Murray et al. 1982; Johnson et al. 1986a, b). This family of snails is considered to be ovoviviparous, although viviparity may be a more accurate description, as considerable growth occurs in utero. Some species in the family are known to be self-fertile while other partulids, including Samoana conica of Tutuila, rely predominantly on out-crossing (Johnson et al. 1986a). In the genus Partula, shell length at birth is 0.12 to 0.14 inches (in) (3 to 3.5 millimeters (mm)) and sexual maturity is attained in less than one year at a shell length of 0.43

to 1.18 in (11 to 30 mm), depending on the species. Adults live about 5 years and give birth about every 20 days, producing about 18 offspring per year (Cowie 1992). Partulids are slow growing and hermaphroditic (Cowie 1992, pp. 167, 174). Eggs develop within the maternal body and hatch within or immediately after extrusion; they may or may not receive nourishment directly from the parent prior to extrusion (Cowie 1992, p. 174). Some species in the family are known to be self-fertile, but most partulids rely predominantly on out- crossing (Cowie 1992, pp. 167, 174). (USFWS, 2014; USFWS, 2016b)

Geographic or Habitat Restraints or Barriers

Adult: Unknown

Spatial Arrangements of the Population

Adult: unknown

Environmental Specificity

Adult: Generalist

Tolerance Ranges/Thresholds

Adult: Unknown

Site Fidelity

Adult: Likely high

Dependency on Other Individuals or Species for Habitat

Adult: Unknown

Habitat Narrative

Adult: Cooke (1928) suggested that habitat partitioning may occur among the three partulids of Tutuila. Samoana conica and S. abbreviata were commonly found on trunks and branches, and the Tutuila tree snail was commonly found on leaves. A similar partitioning of habitat has been reported for the Partula of the Society Islands (Murray et al. 1982). The snails are typically found scattered on understory vegetation in forest with intact canopy 33 to 66 feet (ft) (10 to 20 meters (m)) above the ground (Cowie and Cook 1999; Cowie 2001). (USFWS, 2014)

Dispersal/Migration

Motility/Mobility

Adult: low

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory

Dispersal

Adult: low

Immigration/Emigration

Adult: unlikely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Adult: not applicable

Dispersal/Migration Narrative

Adult: There is not a lot of information regarding the dispersal of this species

Population Information and Trends

Population Trends:

Declining (USFWS, 2014)

Species Trends:

Declining (USFWS, 2014)

Resiliency:

Low

Representation:

Low

Redundancy:

Low

Population Growth Rate:

unknown

Number of Populations:

unknown

Population Size:

unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

Low

Population Narrative:

In a 1993 survey, 34 individuals of the Tutuila tree snails were seen alive; 11 at Sauma Ridge at 400 to 551 ft (122 to168 m) in elevation) and 23 on Nu'usetoga Island at 239 ft (73 m) in elevation, about 328 ft (100 m) offshore of Tutuila (Miller 1993). In a 1998 survey, the Tutuila tree snail was seen alive at 30 of 87 survey sites on the main island of Tutuila and at 1 of 58 sites in the Manua Islands (Cowie and Cook 1999; Cowie 2001). Cowie (2001) compared the long term changes based on observations from his 1998 survey and earlier work done in 1993 (Miller

1993), 1975 (Solem 1975; Christensen 1980), and pre-1975. Of 12 endemic terrestrial species recorded alive in 1975, living individuals of five species and the shells of two additional species were seen in 1993. In 1998, 11 species were seen alive and shells from one additional species were found. Cowie (2001) characterized 3 of these 12 species as being stable in numbers and the rest were described as declining in numbers, including all 4 of the Partula species found in American Samoa. These survey data indicate that the native snail fauna is declining and that the partulid tree snails and several other terrestrial and arboreal species are of particular concern (Cowie 2001). In recent surveys of Tau and Ofu (Cowie and Cook 1999, 2001), the Tutuila tree snail was discovered on the island of Ofu. Eighty-eight individuals were recorded at the single locality. Ofu does not yet have the rosy carnivore snail (Euglandina rosea) (see section on Disease or Predation below). Hence the Ofu population of the Tutuila tree snail is of major conservation significance.

Threats and Stressors

Stressor: Habitat loss and degradation by agriculture (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Several thousand years of subsistence agriculture and more recent plantation agriculture has resulted in the alteration and great reduction in area of forests on the relatively flat land at lower elevations throughout American Samoa (Whistler 1994, p. 40; Mueller-Dombois and Fosberg 1998, p. 361). The threat of land conversion to unsuitable habitat (i.e., steep topography at elevations above the coastal plain) will accelerate if the human population continues to grow or if the changes in the economy shift toward commercial agriculture (DMWR 2006, p. 71). (USFWS, 2016b)

Stressor: Habitat Destruction or Modification by Feral Pigs (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Feral pigs are known to cause deleterious impacts to ecosystem processes and functions throughout their worldwide distribution (Aplet et al. 1991, p. 56; Anderson and Stone 1993, p. 201; Campbell and Long 2009, p. 2,319). Feral pigs are extremely destructive and have both direct and indirect impacts on native plant communities. Pigs are a major vector for the establishment and spread of invasive, nonnative plant species by dispersing plant seeds on their hooves and fur, and in their feces (Diong 1982, pp. 169–170, 196–197), which also serve to fertilize disturbed soil (Siemann et al. 2009, p. 547). In addition, pig rooting and wallowing contributes to erosion by clearing vegetation and creating large areas of disturbed soil, especially on slopes (Smith 1985, pp. 190, 192, 196, 200, 204, 230–231; Stone 1985, pp. 254– 255, 262–264; Tomich 1986, pp. 120– 126; Cuddihy and Stone 1990, pp. 64– 65; Aplet et al. 1991, p. 56; Loope et al. 1991, pp. 18–19; Gagne and Cuddihy 1999, p. 52; Nogueira-Filho et al. 2009, p. 3,681; CNMI–SWARS 2010, p. 15; Dunkell et al. 2011, pp. 175–177; Kessler 2011, pp. 320, 323). (USFWS, 2016b)

Stressor: Habitat Destruction and Modification by Nonnative Plant Species (USFWS, 2016b)
Exposure:
Response:

Consequence:
Narrative: Nonnative plant species can seriously modify native habitat and render it unsuitable for native snail species (Hadfield 1986, p. 325). Although some Hawaiian tree snails have been recorded on nonnative vegetation, it is more generally the case that native snails throughout the Pacific are specialized to survive only on the native plants with which they have evolved (Cowie 2001, p. 219). Cowie (2001, p. 219) reported few observations of native snails, including Eua zebrina, in disturbed habitats on Tutuila. Nonnative plants can degrade native habitat in Pacific island environments by: (1) Modifying the availability of light through alterations of the canopy structure; (2) altering soil–water regimes; (3) modifying nutrient cycling; (4) ultimately converting native- dominated plant communities to nonnative plant communities; and (5) increasing the frequency of landslides and erosion (Smith 1985, pp. 217–218; Cuddihy and Stone, 1990, p. 74; Matson 1990, p. 245; D'Antonio and Vitousek 1992, p. 73; Vitousek et al. 1997, pp. 6– 9; Atkinson and Medeiros 2006, p. 16). (USFWS, 2016b)

Stressor: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: We maintain that collection for scientific purposes likely contributed to a reduction in the number of E. zebrina in the wild; however, we recognize that at the time the majority of collections were made for scientific purposes, E. zebrina was neither at risk of extinction nor did the numbers collected increase the risk of its extinction. In American Samoa, thousands of partulid tree snail shells (mostly E. zebrina) have been collected and used for decorative purposes (e.g., chandeliers) (Cowie 1993, pp. 1, 9). In general, the collection of tree snails persists to this day, and the market for rare tree snails serves as an incentive to collect them. A recent search of the Internet found a Web site advertising the sale of E. zebrina as well as three other Partulid species (Conchology, Inc. 2015, in litt.). Based on the history of collection of E. zebrina, the evidence of its sale on the Internet, and the vulnerability of the small remaining populations of this species, we consider over-collection for commercial and recreational purposes to be a threat to the continued existence of E. zebrina. (USFWS, 2016b)

Stressor: Predation by non-native snails (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: At present, the major existing threat to long-term survival of the native snail fauna in American Samoa is predation by the nonnative rosy wolf snail, the most commonly recommended biological control agent of the giant African snail (Achatina fulica), which also is an invasive nonnative species in American Samoa. In 1980, the rosy wolf snail was released on Tutuila to control the giant African snail (Lai and Nakahara 1980 as cited in Miller 1993, p. 9). By 1984, the rosy wolf snail was considered to be well established on Tutuila, having reached the mountains (Eldredge 1988, pp. 122, 124–125), and by 2001 was reported as widespread within the National Park of American Samoa on Tutuila (Cowie and Cook 2001, pp. 156–157). While there are no records of introduction of the rosy wolf snail to the Manua Islands (Ofu, Olosega, and Tau), this species has been reported on Tau (Miller 1993, p. 10). The absence of the rosy wolf snail on the islands of Ofu and Olosega is significant because E. zebrina is present on Ofu (Miller 1993, p. 10, Cowie and Cook 2001, p. 143; Cowie et al. 2003, p. 39). Numerous studies show that

the rosy wolf snail feeds on endemic island snails and is a major agent in their declines and extinctions (Hadfield and Mountain 1981, p. 357; Howarth 1983, p. 240, 1985, p. 161, 1991, p. 489; Clarke et al. 1984, pp. 101–103; Hadfield 1986, p. 327; Murray et al. 1988, pp. 150–153; Hadfield et al. 1993, pp. 616–620; Cowie 2001, p. 219). (USFWS, 2016b)

Stressor: Predation by the New Guinea or Snail- Eating Flatworm (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Predation by the nonnative New Guinea or snail-eating flatworm (Platydemus manokwari) is a threat to E. zebrina. The extinction of native land snails on several Pacific Islands has been attributed to this terrestrial flatworm, native to western New Guinea (Ohbayashi et al. 2007, p. 483; Sugiura 2010, p. 1,499). The New Guinea flatworm was released in an unsanctioned effort to control the giant African snail (Achatina fulica) in Samoa in the 1990s (Cowie and Cook 1999, p. 47). In 2002, this species was likely present within the Samoan archipelago but was not yet introduced to American Samoa (Cowie 2002, p. 18). However, by 2004, this predatory flatworm had been found on the islands of Tutuila and Tau (Craig 2009, p. 84). (USFWS, 2016b)

Stressor: Predation by rats (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Rats are likely responsible for the greatest number of animal extinctions on islands throughout the world, including extinctions of various snail species (Towns et al. 2006, p. 88). Rats are known to prey upon arboreal snails endemic to Pacific islands and can devastate populations (Hadfield et al. 1993, p. 621). Rat predation on tree snails has been observed on the Hawaiian Islands of Lanai (Hobdy 1993, p. 208; Hadfield 2005, in litt, p. 4), Molokai (Hadfield and Saufler 2009, p. 1,595), and Maui (Hadfield 2006, in litt.). Three species of rats are present in American Samoa: The Polynesian rat, probably introduced by early Polynesian colonizers, and Norway and black rats, both introduced subsequent to western contact (Atkinson 1985, p. 38; Cowie and Cook 1999, p. 47; DMWR 2006, p. 22). Polynesian and Norway rats are considered abundant in American Samoa, but insufficient data exist on the populations of black rats (DMWR 2006, p. 22). (USFWS, 2016b)

Stressor: Hurricanes (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Hurricanes are a common natural disturbance in the tropical Pacific and have occurred in American Samoa with varying frequency and intensity (see Factor E discussion for the Pacific sheath-tailed bat). Hurricanes may adversely impact the habitat of E. zebrina by destroying vegetation, opening the canopy, and thus modifying the availability of light and moisture, and creating disturbed areas conducive to invasion by nonnative plant species (Elmqvist et al. 1994, p. 387; Asner and Goldstein 1997, p. 148; Harrington et al. 1997, pp. 539–540; Lugo 2008, pp. 373– 375, 386). Such impacts destroy or modify habitat elements (e.g., stem, branch, and leaf surfaces, undisturbed ground, and leaf litter) required to meet the snails' basic life-history requirements. In addition, high winds and intense rains from hurricanes can also dislodge individual snails from the leaves and branches of their host plants and deposit them on the forest

floor where they may be crushed by falling vegetation or exposed to predation by nonnative rats and snails (see ‘‘Disease or Predation,’’ above) (Hadfield 2011, pers. comm.). (USFWS, 2016b)

Stressor: Low Numbers of Individuals and Populations (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Species that undergo significant habitat loss and degradation and other threats resulting in decline and range reduction are inherently highly vulnerable to extinction resulting from localized catastrophes such as severe storms or disease outbreaks, climate change effects, and demographic stochasticity (Gilpin and Soule ´ 1986, pp. 24–34; Pimm et al. 1988, p. 757; Mangel and Tier 1994, p. 607). Conditions leading to this level of vulnerability are easily reached by island species that face numerous threats such as those described above for E. zebrina. Small, isolated populations that are diminished by habitat loss, predation, and other threats can exhibit reduced levels of genetic variability, which can diminish the species’ capacity to adapt to environmental changes, thereby increasing the risk of inbreeding depression and reducing the probability of long-term persistence (Shaffer 1981, p. 131; Gilpin and Soule ´ 1986, pp. 24– 34; Pimm et al. 1988, p. 757). (USFWS, 2016b)

Stressor: Climate change (USFWS, 2016b)
Exposure:
Response:
Consequence:
Narrative: Although the USFWS does not have specific information on the impacts of the effects of climate change to E. zebrina, increased ambient temperature and precipitation and increased severity of hurricanes will likely exacerbate other threats to this species as well as provide additional stresses on its habitat. The probability of species extinction as a result of climate change impacts increases when its range is restricted, habitat decreases, and numbers of populations decline (IPCC 2007, p. 48). Eua zebrina is limited by its restricted range in small areas on two islands and small total population size. Therefore, we expect this species to be particularly vulnerable to environmental impacts of climate change and subsequent impacts to its habitat. (USFWS, 2016b)

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- Develop and implement long-term monitoring surveys for the Tutuila snail
- Develop and implement nonnative predatory snail removal and control program
- Develop and implement nonnative flatworm removal and control program
- Control and remove nonnative rat populations
- Conduct habitat restoration and remove invasive plants species

References

USFWS. 2014. Eua zebrina Species Assessment and Listing Priority Assignment Form, U.S. Fish and Wildlife Service.

USFWS. 2016. Eua zebrina. Environmental Conservation Online System (ECOS). http://ecos.fws.gov/ecp0/

USFWS. 2016b. Endangered Status for Five Species From American Samoa

Final Rule. 81 Federal Register 184, Pages 65466-65508.

USFWS. 2014. U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

USFWS. 2016b. Endangered and Threatened Wildlife and Plants

Endangered Status for Five Species From American Samoa

Final Rule. Federal Register Vol. 81, No. 184, p. 65466-65508

SPECIES ACCOUNT: *Helminthoglypta walkeriana* (Morro shoulderband (=Banded dune) snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; Proposed reclassification to threatened

Physical Description

The Morro shoulderband snail (Helminthoglypta walkeriana) is a terrestrial snail in the family Helminthoglyptidae. The shell of the Morro shoulderband snail has five to six whorls. Its dimensions are 18 to 29 millimeters (mm) (0.7 to 1.1 inches [in.]) in diameter and 14 to 25 mm (0.6 to 1.0 in.) in height. The Morro shoulderband snail has spiral striae (longitudinal ridges) as well as transverse striae, giving it a ‘‘checkerboard’’ appearance. Furthermore, there are raised papillae (bumps) at the intersections of some of the striae. The Morro shoulderband’s spire is low-domed, and half or more of the umbilicus (the cavity in the center of the base of a spiral shell that is surrounded by the whorls) is covered by the apertural (small opening) lip. The Morro shoulderband snail has mouth parts (radula) consistent with other snails that eat decaying material and mycorrhiza (a root fungus) (USFWS, 2001; USFWS, 2006).

Taxonomy

The Morro shoulderband snail was first described as the banded dune snail (Helix walkeriana) by Hemphill in 1911. At the time of listing, it was considered to be a single species composed of two subspecies or varieties (H. w. walkeriana and H. w. morroensis). Recent studies by Roth and Tupen have resulted in the recognition of these two subspecies as full species. Because of the potential for the taxonomic change to cause confusion, the following names are used: banded dune snail refers to the both H. w. walkeriana and H. w. morroensis when referring to the entity that was listed; the Morro shoulderband snail refers to H. walkeriana; and Chorro shoulderband snail refers to H. morroensis. The Morro shoulderband snail belongs to the class Gastropoda and family Helminthoglyptidae (USFWS, 1994; USFWS, 2006).

Historical Range

Historically, the species was originally collected ‘‘near Morro, California’’ by Hemphill in 1911. At the time of listing, the known range of the banded dune snail was thought to be "...restricted to sandy soils of coastal dune and coastal sage scrub communities near Morro Bay." Surveys in 1985 resulted in the discovery of only six live Morro shoulderband snails, while empty shells were much more numerous. Although cautioning that not enough data were available to make a more accurate estimate, a species expert speculated that as few as several hundred individuals then existed in the remaining population of Morro shoulderband snails. Experts conducted a limited search for the snail in April 1992 and found no living individuals. However, the expert believed that even though no live snails were found, the limited nature of the survey along with the drought of the previous 4 years would preclude him from concluding that the species was extinct (USFWS, 1994).

Current Range

The Morro shoulderband snail is found only in western San Luis Obispo County in the Los Osos/Morro Bay area. Its currently known range is slightly expanded, to approximately 3.2 kilometers (2 miles) farther to the south and east than known at the time of listing; and it is also now known to occupy a narrow strip of dune vegetation north of Morro Bay. The range includes areas south of Morro Bay, west of Los Osos Creek, and north of Hazard Canyon (66 FR 9233). Its known range now comprises approximately 3,100 hectares (ha) (7,700 acres [ac.]) (USFWS 2006).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 3/9/2001.

Legal Description

On February 7, 2001, the U.S. Fish and Wildlife Service (Service), designated critical habitat (effective March 9, 2001) for the Morro shoulderband snail (Helminthoglypta walkeriana) pursuant to the Endangered Species Act of 1973, as amended (Act). The Morro shoulderband snail is listed as endangered under the Act. A total of approximately 1,039 hectares (2,566 acres) fall within the boundaries of designated critical habitat.

Critical Habitat Designation

Lands designated as critical habitat have been divided into three Critical Habitat Units totaling approximately 2,566 acres (1,039 hectares) in San Luis Obispo County, California. Brief descriptions are provided below; maps are included in the Final Rule (USFWS, 2001).

Map Units 1 to 3: All located in San Luis Obispo County, California. Coastline boundaries are based upon the U.S. Geological Survey Morro Bay South 7.5 minute topographic quadrangle. Other boundaries are based upon the Public Land Survey System. Within the historical boundaries of the Canada De Los Osos Y Pecho Y Islay Mexican Land Grant, boundaries are based upon section lines that are extensions to the Public Land Survey System developed by the California Department of Forestry and obtained by us from the State of California's Stephen P. Teale Data Center. Township and Range numbering is derived from the Mount Diablo Base and Meridian. (USFWS, 2001)

Unit 1: MORRO SPIT AND WEST PECHO. Unit 1 encompasses areas managed by Montaña de Oro State Park (Dunes Natural Preserve) and the City of Morro Bay (north end of spit), including the length of the spit and the foredune areas extending south toward Hazard Canyon. Map Unit 1: T. 29 S., R. 10 E., all of section 35 above mean sea level (MSL); T. 30 S., R. 10 E. All portions of sections 1, 2, 11, 12, 14, 22, and 27 above MSL, SW/ 1/4 /NW/ 1/4 / section 13 above MSL, W/ 1/2 /NW/ 1/4 / section 24, all of section 23 above MSL except S/ 1/2 /SE/ 1/4 /, NW/ 1/4 /NW/ 1/4 / section 26, N/ 1/2 /N/ 1/2 section 34.

UNIT 2: SOUTH LOS OSOS. Unit 2 is bounded on the north and east by residential development in the community of Los Osos and agricultural fields. Map Unit 2: T. 30 S., R. 10 E., E/ 1/2 /NE/ 1/4 section 24; T. 30 S., R, 11 E., E/ 3/4 /N/ 1/2 / section 19. (USFWS, 2001)

UNIT 3: NORTHEAST LOS OSOS. The Northeast Los Osos Critical Habitat Unit includes undeveloped areas between Los Osos Creek and Baywood Park and is divided by South Bay Boulevard. Map Unit 3: T. 30 S., R. 11 E., All of NE/ 1/4 section 7 above MSL; in section 8, NW/ 1/4 /NW/ 1/4, S/ 1/2 /NW/ 1/4, SW/ 1/4 /, and NW/ 1/4 /SE/ 1/4 /. (USFWS, 2001)

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for San Luis Obispo County, California. Within these areas, the primary constituent elements include, but are not limited to, those habitat components that are essential for the primary biological needs of foraging, sheltering, reproduction, and dispersal. The primary constituent elements for the Morro shoulderband snail are the following:

(i) sand or sandy soils;

(ii) a slope not greater than 10 percent; and

(iii) the presence of, or the capacity to develop, coastal dune scrub vegetation.

Special Management Considerations or Protections

Critical habitat does not include existing developed sites consisting of buildings, roads, aqueducts, railroads, airports, paved areas, and similar features and structures.

Special management needs include controlling non-native pest plants to maintain intact native habitat, restoring and maintaining connectivity among isolated populations to preserve genetic diversity, controlling pesticides in snail areas, controlling non-native predatory snails, and restoring native plant communities.

Life History

Feeding Narrative

Adult: The Morro shoulderband snail is a detritivore that feeds on decaying plant material. Though not much is known about the species' feeding, it is suspected that the snail feeds mostly on fungal mycelia and/or mycorrhiza. The species has also been observed to consume fruits and vegetables when present in the laboratory. It is thought that the snail has no natural competition for food. The Morro shoulderband snail is not a garden pest and is essentially harmless to gardens (66 FR 9233).

Reproduction Narrative

Adult: Though no studies or documented observations exist on the reproductive behaviors of the Morro shoulderband snail, it is speculated that maturity may be reached, as in other Helminthoglypta that inhabit coastal scrub, sometime between 3 and 4 years of age, and that individuals may live as many as 6 to 10 years. Copulation and reproduction likely occur in the rainy season, as is the case with H. arrosa (65 FR 42962; NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Lower limbs of larger older shrubs may be too far off the ground to offer good shelter, and mature stands produce twiggy litter that is low in food value (66 FR 9233).

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist

Dependency on Other Individuals or Species for Habitat

Adult: Through most of its range, the dominant shrub associated with the snail's habitat is mock heather (Ericameria ericoides). Other prominent shrub and succulent species are buckwheat (Eriogonum parvifolium), eriastrum (Eriastrum densifolium), chamisso lupine (Lupinus chamissonis), and dudleya (Dudleya sp.); and in more inland locations, California sagebrush (Artemisia californica), coyote brush (Baccharis pilularis), and black sage (Salvia mellifera) (USFWS 1998).

Habitat Narrative

Adult: Morro shoulderband snails occur in coastal and scrub communities as well as maritime chaparral. Habitat associations have been recently expanded to include coast live oak woodland, California annual grassland, dune lupine-goldenbush, introduced perennial grassland, and European beachgrass series communities at elevations of 3 to 46 meters (10 to 150 feet) on soils of Baywood find sands, active dune sands, and clay (NatureServe 2015). In general, the communities include grasslands and hardwood forests. Through most of its range, the dominant shrub associated with the snail's habitat is mock heather (Ericameria ericoides). Other prominent shrub and succulent species are buckwheat (Eriogonum parvifolium), eriastrum (Eriastrum densifolium), chamisso lupine (Lupinus chamissonis), and dudleya (Dudleya sp.); and in more inland locations, California sagebrush (Artemisia californica), coyote brush (Baccharis pilularis), and black sage (Salvia mellifera) (USFWS 1998).Immature scrub in earlier successional stages may offer more favorable shelter sites than mature stands of coastal dune scrub. The immature shrubs provide canopy shelter for the snail, whereas the lower limbs of larger older shrubs may be too far off the ground to offer good shelter. The snail relies on the decaying leaf litter in these same sites for their food source (USFWS 2006; NatureServe 2015). In addition, mature stands produce twiggy litter that is low in food value (USFWS 1998).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal/Migration Narrative

Adult: Morro shoulderband snails are a nonmigratory species. They have low mobility throughout their habitat, which limits their range and dispersal (NatureServe 2015).

Population Information and Trends

Population Trends:

Either stable (less than 10 percent short-term decline) or increasing (NatureServe 2015; USFWS 2006).

Species Trends:

Either relatively stable (less than 50 percent long-term decline) or increasing (NatureServe 2015; USFWS 2006).

Resiliency:

Moderate

Representation:

Low

Redundancy:

Low

Number of Populations:

Six to 20 occurrences (NatureServe 2015).

Resistance to Disease:

Moderate; potentially parasitized by sarcophagid fly.

Additional Population-level Information:

Critical habitat is broken up into three units: Unit 1, Morro Spit and West Pecho; Unit 2, South Los Osos; and Unit 3, Northeast Los Osos. These are listed conservation planning areas where the snail has protected critical habitat. Other populations may exist outside of the known critical habitat site areas (66 FR 9233).

Population Narrative:

The Morro shoulderband snail is distributed throughout three critical habitat units in San Luis Obispo County, with 6 to 20 total occurrences documented (18 populations sampled from 2001 through 2003). The historic range was found to be continuously occupied by live individuals in 2003. Few demographic studies and/or population surveys have been conducted. However, at present the species is known from a slightly expanded range. More surveys are conducted every year, with more snails being found every year. This could indicate either that the snail numbers are increasing or simply that surveyors are looking in more places and observing more individuals of a stabilized population. Although not sufficient to determine a population trend, it may be reasonable to infer from these surveys that the snail population is at least either stable or increasing and not decreasing. In the 2006 5-Year Review, the U.S. Fish and Wildlife Service (USFWS) recommended changing the status from endangered to threatened, recognizing that large tracts of lands suitable for the species were conserved in perpetuity, consistent with the objectives established in the recovery plan (USFWS 2006; NatureServe 2015).There have been individuals discovered north of Morro Bay, but no distinct populations have been documented thus far. Critical habitat is broken up into three units: Unit 1, Morro Spit and West Pecho; Unit 2, South Los Osos; and Unit 3, Northeast Los Osos. These are listed conservation planning areas where the snail has protected critical habitat. Other populations may exist outside of the known critical habitat site areas (66 FR 9233; NatureServe 2015). With the current protections implemented, the species population has been stable, with possible increase depending on the accuracy of surveys (66 FR 9233).

Threats and Stressors

Stressor: Development
Exposure: Habitat destruction and degradation due to development.

Response: Reduced habitat, and habitat degradation.
Consequence: Decreased population numbers, and extirpation.
Narrative: Morro shoulderband snail has a very limited distribution, and further habitat loss will cause further population decline (65 FR 42962).

Stressor: Nonnative plants
Exposure: Invasion by nonnative plants such as veldt grass; structural changes in the vegetation due to plant senescence.
Response: Reduced habitat, and habitat degradation.
Consequence: Decreased population numbers, and extirpation.
Narrative: Invasion of nonnative plants causes a structural change to the habitat of the Morro shoulderband snail that may result in the loss of food sources as well as overall habitat (65 FR 42962).

Stressor: Predation
Exposure: Sarcophagid flies (a family of flies that relies on a host to complete its life cycle)
Response: Population decline.
Consequence: Decreased population numbers, and extirpation.
Narrative: Sarcophagid flies (a family of flies that relies on a host to complete its life cycle) have been observed to parasitize the Morro shoulderband snail. Empty puparia (''cases'' left behind by adult flies emerging from pupae) were observed in empty snail shells by Hill, Roth, and Kim Touneh. Hill and Roth suggested that mortality from infestations of larvae of this parasitic fly often occurs before the snails reach reproductive maturity. Based on shell examination, Roth also suggested that rodents may prey on the snail (65 FR 42962).Morro shoulderband snail has a very limited distribution, and possible parasitation will cause further population decline. The flies may have a significant impact on the population of the snail (65 FR 42962).

Stressor: Habitat management
Exposure: Controlled burning of coastal scrub to improve habitat for endangered Morro Bay kangaroo rat (Dipodomys heermanni morroensis).
Response: Population decline.
Consequence: Decreased population numbers, and extirpation.
Narrative: Several Morro shoulderband snails were killed as a result of controlled burning of coastal scrub to improve habitat for endangered Morro Bay kangaroo rat in Montana de Oro state park. This has led the California Department of Parks and Recreation to conduct snail surveys prior to conducting any controlled burns in the Morro Bay area (USFWS 2006).

Stressor: Nonnative snails
Exposure: The introduction of nonnative predatory snail species by humans.
Response:
Consequence: Decreased population numbers, and extirpation.
Narrative: Nonnative predatory snails could possibly feed on Morro shoulderband snails. Although these snails were introduced to aid in removing nonnative garden snails, they have been shown to be indiscriminate with regard to choosing prey, including native California snail species. The importation and transportation of nonnative snails are prohibited in San Luis Obispo County by the California Department of Fish and Game (USFWS 1998).

Stressor: Use of pesticides

Exposure: Snail and slug baits generally used to remove pest species.
Response:
Consequence: Decreased population numbers, and extirpation.
Narrative: Snail and slug baits generally used to remove pest species such as the brown garden snail can also be harmful to and cause mortality in Morro shoulderband snails. Bait use is more widespread in urban areas such as Los Osos, and could cause a decline in snail populations (USFWS 1998).

Stressor: Small population size
Exposure: Small population size.
Response: Less genetic variability.
Consequence: Decreased population numbers, and extirpation.
Narrative: Smaller populations of Morro shoulderband snails are more susceptible to being extirpated due to sudden habitat changes or other natural events. There is also less genetic variability in smaller populations, making them more susceptible to disease (NatureServe 2015).

Recovery

Reclassification Criteria:
1. Sufficient populations and suitable habitats from all four conservation planning areas (Morro Spit, West Pecho, South Los Osos, and Northeast Los Osos) are secured and protected. These areas should be intact and relatively unfragmented by urban development. Snail populations must be large enough to minimize the short-term (next 50 years) risk of extinction on any of the four conservation planning areas, based on the results of tasks 3.2.1.1, 3.2.1.2, and 3.2.1.3, and on at least preliminary results from task 4.1 of the recovery actions. (USFWS 1998)

2. Potential habitat within the snail's historic range will have been identified and surveyed to see if undiscovered populations exist. Should surveys locate additional populations, especially north of Morro Bay, recovery criteria will have to be evaluated and revised. (USFWS 1998)

Delisting Criteria:
1. Sufficient populations and suitable habitats (as shown by life history studies) to ensure long-term persistence in each of the four Conservation Planning Areas must be secured from the threat of development. (USFWS, 2019)

2. These sites must be under permanent management to maintain the desired vegetation structure and to ameliorate negative impacts of structural changes due to senescence of dune vegetation. (USFWS, 2019)

3. Other threats, including invasion of non-native plants, competition or predation from non-native snails, impacts from recreational use and the use of pesticides, have been assessed and effectively controlled or removed. (USFWS, 2019)

Recovery Actions:
- Secure populations and habitat on unprotected lands. Methods for securing lands include in-fee purchase, gifts of easement or fee interest by the property owner, deed restrictions (provided restrictions cannot be changed privately without the knowledge of Federal, State

and County agencies), acquisition of property rights (e.g., development rights) or permanent conservation easements. (USFWS, 1998)

- Manage secured lands to control or eliminate other known threats. Although habitat alteration through development is currently the most substantial and irreversible threat facing all of the species in this plan, the management of lands secured from development will remain a formidable task, made more so in those cases where the secured habitats are adjacent to high-density residential and urban development. (USFWS 1998)
- Evaluate potential threats and conduct management-oriented research. Conduct habitat-oriented research for Morro Bay species. Conduct species-specific research. Evaluate research results and use in future management. (USFWS, 1998)
- Determine population dynamics and effects of recovery efforts. Studies should be conducted to learn the number and size of successful self-sustaining populations for each species to establish criteria for their reclassification. (USFWS 1998)
- Develop and implement an education/information program. The benefits of protecting native species and their habitats and maintaining native biological communities should be explained clearly to all concerned parties. (USFWS 1998).
- Reevaluate recovery criteria and revise recovery plan based on expanded knowledge from research, monitoring, and management. The scientific validity of the recovery criteria and recovery plan should be reviewed and revised as more information becomes available. The criterion of maintaining sufficient numbers of populations or conservation areas should be assessed, and the success or failure of management actions should be evaluated. (USFWS 1998)
- Recommendation for Future Action from 2006 5-Year Review: Along with the preparation of a rule to downlist the Morro shoulderband snail, develop a section 4(d) rule under the Endangered Species Act that encourages and facilitates the development of a regional (community-wide) plan for the snail (and other listed dune scrub species), while still allowing certain activities (e.g., the building of single family houses on vacant lots in urban areas that are away from the preserves and /or critical habitat) that may result in take of individuals that are not essential to the survival and recovery of the species (USFWS 2006).
- Recommendation for Future Action from 2006 5-Year Review: Revise the recovery plan and recovery criteria to eliminate those threats that have been shown to not exist, and concentrate future efforts where needed (USFWS 2006).
- Recommendation for Future Action from 2006 5-Year Review: Work with others to conserve lands and habitat that are important for the Morro shoulderband snail, including lands in all four of the conservation planning areas, "other habitats," and the "potential restoration corridor," as identified in the recovery plan (see Figure 1, pp. 36 and 37, Figure 8 on p. 39, and pp 43 and 44) (USFWS 2006).
- Recommendation for Future Action from 2006 5-Year Review: As per the recovery plan (pp. 46 through 49), work with others to manage the lands that serve as preserves for the Morro shoulderband snail (e.g., "Powell Parcel," "Butte Driver," and "Hotel Site"). Many lands are conserved for the Morro shoulderband snail, but very few of these conserved lands are managed for the Morro shoulderband snail (USFWS 2006).

Conservation Measures and Best Management Practices:

- All potential project sites in the vicinity of Morro shoulderband snail critical habitat will require presence/absence surveys to be conducted. Surveys shall be conducted in the rain or immediately after a rain event. A property shall be subject to a minimum of five visual surveys spaced 1 week apart. Morro shoulderband surveys should not be conducted during dry weather conditions. It is important not to disturb microclimates in leaf litter where the species may be aestivating. Surveys must be documented, and the USFWS must be contacted if more than 2 years have passed since a negative survey resulted on the given site (USFWS 2003).

Additional Threshold Information:

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SPECIES ACCOUNT: *Juturnia kosteri* (Koster's springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/09/2005; Southwest Region (R2) (USFWS, 2016)

Physical Description

Thermal spring snail of the family Hydrobiidae endemic to springs in the Roswell area of the Pecos River Valley. See Taylor (1987) for morphological description.Very small with a pale tan shell that is narrowly conical with up to 1.25 to 5.75 whorls (FWS, 2005). (NatureServe, 2015)

Taxonomy

Although their shells are similar, the Roswell springsnail is distinguished from Koster's springsnail by a dark, amber operculum (a lid which closes the shell opening when the animal is retracted) with white spiral streaks, while that of Koster's springsnail is nearly colorless. The genus Assiminea can be determined from other snail genera by an almost complete lack of tentacles, leaving the eyes within the tips of short eye stalks (Taylor 1987) (USFWS, 2005).

Current Range

It is endemic to springs in the Roswell area of the Pecos River Valley in New Mexico. Less than 9 km exists between the most distant populations. Pleistocene fossils are known from nearby sites up to 20 km away.

Critical Habitat Designated

Yes; 8/9/2005.

Legal Description

On June 7, 2011, the U.S. fish and Wildlife Service designated critical habitat for Juturnia kosteri.

Critical Habitat Designation

Approximately 70.2 ac (28.4 ha) in two units in New Mexico is designated as critical habitat for the Roswell springsnail and Koster's springsnail.

Unit 1: Sago/Bitter Creek Complex. Unit 1 consists of 31.9 ac (12.9 ha) of habitat that was occupied by all four invertebrates (Pecos assiminea (Assiminea pecos), Roswell springsnail (Pyrgulopsis roswellensis), Koster's springsnail (Juturnia kosteri), and Noel's amphipod (Gammarus desperatus)) at the time of listing and that remains occupied at the present time. This unit contains all of the physical and biological features essential to the conservation of these species. Unit 1 is located on the northern portion of the Middle Tract of Bitter Lake National Wildlife Refuge, Chaves County, New Mexico. The designation includes all springs, seeps, sinkholes, and outflows surrounding Bitter Creek and the Sago Springs complex. Habitat in this unit is in need of special management because of threats by subsurface oil and gas drilling or similar activities that contaminate surface drainage or aquifer water; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. The entire unit is owned by the Service.

Unit 2a: Springsnail/Amphipod Impoundment Complex. Unit 2a consists of 38.3 ac (15.5 ha) of habitat that was occupied by three of the four invertebrates at the time of listing and that remains occupied at the present time. This unit is designated as critical habitat for Roswell springsnail, Koster's springsnail, and Noel's amphipod; it contains all of the physical and biological features essential to the conservation of these species. Unit 2a is located on the southern portion of the Middle Tract of Bitter Lake National Wildlife Refuge and on property owned by the City of Roswell, Chaves County, New Mexico. This unit includes portions of impoundments 3, 6, 7, and 15, and Hunter Marsh. The designation includes all springs, seeps, sinkholes, and outflows surrounding the Refuge impoundments. Habitat in this unit is threatened by subsurface drilling for oil and gas or similar activities that contaminate surface drainage or aquifer water; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. Land ownership in this unit includes the Service and the City of Roswell, New Mexico.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Chaves County, New Mexico. The primary constituent element of critical habitat for the Koster's springsnail and Roswell springsnail is springs and spring-fed wetland systems that:

(i) Have permanent, flowing water with no or no more than low levels of pollutants;

(ii) Have slow to moderate water velocities;

(iii) Have substrates ranging from deep organic silts to limestone cobble and gypsum;

(iv) Have stable water levels with natural diurnal (daily) and seasonal variations;

(v) Consist of fresh to moderately saline water;

(vi) Vary in temperature between 50– 68 °F (10–20 °C) with natural seasonal and diurnal variations slightly above and below that range; and

(vii) Provide abundant food, consisting of: (A) Algae, bacteria, and decaying organic material; and (B) Submergent vegetation that contributes the necessary nutrients, detritus, and bacteria on which these species forage.

Special Management Considerations or Protections

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 the effective date of the final rule.

Special management considerations are needed to protect the habitat of this species from the loss or alteration of spring habitat as a result of drought or pumping.

Special management efforts are needed to protect habitat of this species from the potential effects of water contamination from oil and gas operations, agricultural activities, wastewater effluent, and stormwater runoff.

Special management efforts are needed to correctly plan prescribed fires in order to protect habitat of this species from the potential effects of wildfire.

Special management efforts are needed to protect this species from the potential effects of invasive, nonnative terrestrial plants and invasive, nonnative snails.

Life History

Feeding Narrative

Adult: The snails feed on algae, bacteria, and decaying organic matter; and will incidentally ingest small invertebrates while grazing on algae and detritus (USFWS, 2010).; The Roswell springsnail and Koster's springsnail have lifespans of 9 to 15 months and reproduce several times during the spring through fall breeding season (Taylor, 1987; Pennak, 1989). No information exists on frequency of breeding, fecundity, or other aspects of reproduction of Pecos assiminea.; (NatureServe, 2015).

Reproduction Narrative

Adult: Lifespan of 9 to 12 months and reproduced several times during the spring through fall breeding season; also sexually dimorphic with females characteristically larger and longer-lived than males (FWS, 2005).; Assiminea pecos, Juturnia kosteri, Pyrgulopsis roswellensis, and the amphipod Gammarus desperatus are often found together associated with aquifer-fed, spring systems in desert grasslands of the Pecos River basin with abundant "karst" topography (USFWS, 2010). ; (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: Species is found on pebbles, gypsum silt and to a lesser extent mud and submerged vegetation in seeps and high volume springs and spring runs. Co-occurs with TRYONIA KOSTERI. Occupies spring heads and runs with variable water temperatures (10-20C) and slow-to-moderate water velocities over compact substrate ranging from deep organic silts to gypsum sands and gravel and compact substrate (FWS, 2005). Benthic (NatureServe, 2015). Clumped arrangements of the population, narrow environmental specificity, high ecological integrity of the community, high site fidelity and low tolerance ranges are based on the species specific habitat requirements, small geographic range and low number of known populations.

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: Unlikely (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Low mobility and dispersal as well as unlikely immigration are based on the snails specific habitat requirements, isolated populations and physiological characteristics as does the species being classified as non-migrant (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1000 - 10,000 individuals (NatureServe, 2015)

Population Narrative:

Dependent on flowing water of high quality, although it can be mineral rich. Localized range, limited mobility, fragmented habitat (FWS, 2005). Decline of 50-70%. Well over 10,000 individuals restricted to less than 3 km of spring/stream habitat. Enormous population on Bitter Creek; abundant at Sago Spring; small populations at the seep and disturbed spring. The entire distribution appears to be restricted to Bitter Lake National Wildlife Refuge (NM Game and Fish, 2004). It is known from two high volume springs and spring runs, one seep, and one highly modified spring (Lake St. Francis, Dragonfly Spring, Bitter Creek, Sago Spring, Sinkhole No. 31, southwestern corner of Unit 15, northwestern border of Hunter Marsh, and isolated locations along the western boundaries of Unites 5, 6, 7). Apparently extirpated from a second seep

(North Spring east of Roswell at Roswell Country Club) (FWS, 2005) (NatureServe, 2015). Low representation, resiliency and redundancy are based on the species habitat requirements and low number of populations.

Threats and Stressors

Stressor: Reduction of Water in Springs (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: These four invertebrates depend on water for survival. Therefore, the loss or alteration of spring habitat continues to be the main threat to each of the four invertebrates. The scattered distribution of springs makes them aquatic islands of unique habitat in an arid-land matrix (Myers and Resh 1999). Members of the snail family Hydrobiidae (including Roswell and Koster's springsnails) are susceptible to extirpation or extinction because they often occur in isolated desert springs (Hershler 1989, Hershler and Pratt 1990, Hershler 1994, Lydeard et al. 2004). There is evidence these habitats have been historically reduced or eliminated by aquifer depletion (Jones and Balleau 1996). The lowering of water tables through aquifer withdrawals for irrigation and municipal use has degraded desert spring habitats, which the three snails and Noel's amphipod depend upon for survival. At least two historic sites for the invertebrates (South Spring, Lander Spring) are currently dry due to aquifer depletion (Cole 1981, Jones and Balleau 1996), and Berrendo Spring, historical habitat for the Roswell springsnail, is currently at 12 percent of the 1880s flow. However, during the mid-1970s, the areas currently occupied by the species continued to flow, even though groundwater pumping was at its highest rate and the area was experiencing extreme drought (McCord et al. 2007). This suggests these springs and seeps may be somewhat resilient to reduced water levels (USFWS, 2010).

Stressor: Water Contamination (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat/loss of individuals
Narrative: Water contamination, particularly from oil and gas operations, is a significant threat for these four invertebrates. In order to assess the potential for contamination, a study was completed in September 1999 to delineate the area that serves as sources of water for the springs on the Refuge (Balleau Groundwater, Inc. 1999). This study reported that the sources of water that will reach the Refuge's springs include a broad area beginning west of Roswell near Eightmile Draw, extending to the northeast to Salt Creek, and southeast to the Refuge. This area represents possible pathways from which contaminants may enter the groundwater that feeds the springs on the Refuge. This broad area sits within a portion of the Roswell Basin and contains a mosaic of Federal, State, City, and private lands with multiple land uses including expanding urban development (USFWS, 2010).

Stressor: Fire (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The effects of wildfire to these four invertebrate species could be catastrophic and pose a threat to at least the Roswell and Koster's springsnails and Noel's amphipod. As such,

strategically timed prescribed burns throughout their range significantly reduce fuel loads, limiting the risk of detrimental wildfires (USFWS, 2010).

Stressor: Overutilization for commercial, recreational, scientific, or educational purposes (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Roswell springsnail, Koster's springsnail, Pecos assiminea, and Noel's amphipod may occasionally be collected as specimens for scientific study, but these uses have a negligible effect on total population numbers. These species are currently not known to be of commercial value, and overutilization has not been documented. However, as their rarity becomes known, they may become more attractive to collectors. Although scientific collecting is not presently identified as a threat, unregulated collecting by private and institutional collectors could pose a threat to these locally restricted populations. We are aware of overcollection being a potential threat with other snails (e.g., armored snail (Pyrgulopsis (Marstonia) pachyta) (65 FR 10033, February 25, 2000); Bruneau hot springsnail (P. bruneauensis) (58 FR 5938, January 25, 1993); and Socorro springsnail (P. neomexicana) and Alamosa springsnail (Tryonia alamosae) (56 FR 49646, September 30, 1991), due to their rarity, restricted distribution, and generally well known locations. Due to the small number of localities for the four invertebrates, these species are vulnerable to unrestricted collection, vandalism, or other disturbance. There is no documentation of collection as a significant threat to any of the species. Therefore, we believe that collection of the animals is a minor but present threat (USFWS, 2010).

Stressor: Predation (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Springsnails and amphipods are a food source for other aquatic animals. Juvenile springsnails appear vulnerable to a variety of predators. Damselflies (Zygoptera) and dragonflies (Anisoptera) have been observed feeding upon snails in the wild (Mladenka 1992). Damselflies and dragonflies are native and abundant on the Refuge and their aquatic larvae most likely prey upon both the springsnails and Noel's amphipod. Springsnails are vulnerable to predation by fish (Kennedy 1977; Winemiller and Anderson 1997). Mladenka (1992) found that guppies would feed on springsnails in the laboratory. Nonnative fish present on the Refuge (primarily common carp, Cyprinus carpio) most likely also prey upon the springsnails and Noel's amphipod when they occur in the same habitats. The extent to which predation from nonnative fish affects population size of the three aquatic invertebrates is not known. Predation pressure on the semiaquatic Pecos assiminea is also unknown. However, if the decollate snail (Rumina decollata), a nonnative predatory snail, becomes established on the Refuge, the potential exists for it to prey on Pecos assiminea. The decollate snail was introduced to the United States in the early 1800s in South Carolina and spread westward (Selander and Kaufman 1973). It was reported in Arizona in 1952 and California in 1966 but was well established by the time it was discovered (Selander and Kaufman 1973). It is common in Texas (Selander and Kaufman 1973) and has been reported from the Roswell area in New Mexico (Lang 2005b). It inhabits gardens and agricultural areas and is primarily terrestrial, but has also invaded riparian and other native habitats (Selander and Kaufman 1973). It is used in California as a biological control agent against the brown garden snail (Helix aspera) (Cowie 2001). It will consume native snails (Cowie 2001) as well as vegetation

(Dundee 1984). For these reasons, the decollate snail is a potential threat to Pecos assiminea (USFWS, 2010).

Stressor: Predation and competition (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Nonnative aquatic species such as crayfish, fish, and aquatic snails are also a potential threat to the four invertebrates. There are three native and three nonnnative species of crayfish in New Mexico, but their distributions do not overlap with that of the four invertebrates (Hobbs 1991; B. Lang, NMDGF, pers. comm., 2010). Crayfish are typically opportunistic generalists (they will eat anything and everything) (Hobbs 1991) and their predation on invertebrates is well documented (Hobbs 1991; Lodge et al. 1994; Charlebois and Lamberti 1996; Strayer et al. 1999). Additionally, because they also feed on organic debris and vegetation and reduce algal biomass (Charlebois and Lamberti 1996), they could potentially compete with Roswell springsnail, Koster's springsnail, and Noel's amphipod for food resources. Currently nonnative crayfish are not present on the Refuge or the sites in Texas. Diamond Y Springs Complex does have an undescribed native crayfish that we do not believe to be a concern for Pecos assiminea. However, crayfish have created major problems in aquatic systems in Arizona, and there is no physiological reason why some species of crayfish could not survive in the habitats that now support the four invertebrates. Eradication of crayfish once they are established is extremely difficult (Hyatt 2004). Should crayfish become established in habitats occupied by the four invertebrates, crayfish would pose a potential threat via predation and competition. Nonnative fish have had a major impact on native aquatic fauna in the southwest (Minckley and Douglas 1991; Desert Fishes Team 2003). Communities of animals evolved together and developed adaptations to deal with competition and predation from other members of the community (Meffe et al. 1994). When a nonnative species is introduced into this community, the native members often do not have defenses against predation or they may be less successful competitors. As a result, the nonnative species can have a major impact on native populations (Minckley and Douglas 1991; Meffe et al. 1994). Common carp, a nonnative species, is known to co-occur with the three aquatic invertebrates on the Refuge. Native to Asia, common carp was introduced into the United States in 1831, has become widely distributed (Sublette et al. 1990), and is present on the Refuge in habitats occupied by the invertebrates. It is an omnivore that feeds on aquatic invertebrates, fish eggs, algae, plants, and organic matter (Sublette et al. 1990). In addition, through spawning and feeding behavior it uproots vegetation and increases turbidity (Sublette et al. 1990). Because of its non-discriminatory diet and habitat disturbance, the introduced common carp could have an impact on the three aquatic invertebrate species. Mosquitofish (Gambusia affinis) is also present in some of the spring systems on the Refuge, but it is not known if it is native to the area or not. The species is native to portions of New Mexico, but it has also been widely introduced to control mosquitoes (Sublette et al. 1990). However, it has negatively affected or extirpated many native species of fish and invertebrates (e.g., through predation or hybridization) (Meffe et al. 1994). It is not known if mosquitofish are affecting the three species of aquatic invertebrates (USFWS, 2010).

Stressor: Introduced Species (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat

Narrative: Introduced species are one of the most serious threats to native aquatic species (Williams et al. 1989, Lodge et al. 2000). Because the distribution of the four invertebrates is so limited and their habitat is so restricted, introduction of certain nonnative species into their habitat could be devastating. Building upon the list of nonnative aquatic species, such as crayfish, fish, and aquatic snails, discussed under Predation and competition in section 2.3.2.3, below is a discussion of additional nonnative plants and animals that could negatively impact the four invertebrates. Plants Several invasive terrestrial plant species that may affect the invertebrates are present on the Refuge, including saltcedar (Tamarix spp.), common reed, and Russian thistle (tumbleweed) (Salsola spp.). Control and removal of nonnative vegetation is a factor responsible for localized extirpations of populations of Pecos assiminea in Mexico and New Mexico (Taylor 1987), but uncontrolled nonnative vegetation invasion is also likely detrimental to the species. Saltcedar, found on the Refuge and at Diamond Y Spring Complex and East Sandia Spring, threatens spring habitats primarily through displacement of native plants, shading and/or cooling of spring runs, and from the chemical composition of the leaves and sap that drop to the ground and into the springs. Saltcedar leaves that fall to the ground and into the water increase the salinity of the system, as their leaves contain salt glands (DiTomaso 1998). Additionally, dense stands of common reed choke the stream channel, slowing water velocity and creating more pool-like habitat; this habitat is less suitable for Roswell and Koster's springsnails, which prefer flowing water. Finally, Russian thistle (tumbleweed) can create problems in spring systems by being blown into the channel, slowing flow and overloading the system with organic material (Service 2005b). The specific and limited habitat of the four invertebrates is vulnerable to invasion by these introduced plants, posing the potential for habitat degradation by a moderate threat to the four invertebrates. Mollusks Nonnative mollusks have affected the distribution and abundance of native mollusks in the United States. Of particular concern for three of the invertebrates (Noel's amphipod, Roswell springsnail, and Koster's springsnail) is the red-rim melania (Melanoides tuberculatus), a snail that can reach tremendous population sizes and has been found in isolated springs in the west. The red-rim melania has caused the decline and local extirpation of native snail species, and it is considered a threat to endemic aquatic snails that occupy springs and streams in the Bonneville Basin of Utah (Rader et al. 2003). It is easily transported on fishing boats and gear or aquatic plants, and because it reproduces asexually (individuals can develop from unfertilized eggs), a single individual is capable of founding a new population. It has become established in isolated desert spring ecosystems such as Ash Meadows, Nevada, and Cuatro Cienegas, Mexico, and within the last 15 years, the red-rim melania has become established in Diamond Y Springs Complex (Echelle 2001). It has become the most abundant snail in the upper watercourse of the Diamond Y Springs Complex (Echelle 2001). In many locations, this exotic snail is so numerous that it dominates the substrate in the small stream channel. The effect the species is having on native snails is not known; however, because it is aquatic it probably has less effect on Pecos assiminea than on the other endemic aquatic snails present in the spring. Snails The New Zealand mudsnail (Potamopyrgus antipodarum) is also a potential threat to the endemic aquatic snails on the Refuge and the spring systems in Texas. It was discovered in the Snake River, Idaho, in the mid-1980s and has quickly spread to every Western state except New Mexico (Montana State University 2010). Like the red-rim melania, the New Zealand mudsnail has an operculum (a lid to close off the shell opening), can withstand periods of drying up to eight days (thereby facilitating transport) and can reproduce either sexually or asexually. Thus, new populations can be established with transport of a single individual. In addition, the New Zealand mudsnail is tiny (3 mm [0.12 in] in height), is easily overlooked on gear or shoes, and can be transported unknowingly by people visiting various recreational sites. Considering its current rate of expansion and the availability of suitable habitat, it is highly likely that the New Zealand mudsnail will soon be discovered in New Mexico. The New Zealand mudsnail tolerates a wide range of habitats, including brackish water. Densities are usually highest in systems with high primary productivity, constant temperatures, and constant flow (typical of spring systems). It has reached densities exceeding 500,000 per square meter (46,400 per square foot) (Richards et al. 2001) to the detriment of native invertebrates. Not only can it dominate the invertebrate assemblage (97 percent of invertebrate biomass), it can also eat nearly all of the algae and diatoms growing on the substrate, altering ecosystem function at the base of the food web (food is no longer available for native animals) (Hall et al. 2003). If the New Zealand mudsnail is introduced into the spring systems harboring the four invertebrates, control would most likely be impossible because the snails are so small and because any chemical treatment would also affect the native species. The impact could be devastating. Trematodes Infestation by trematodes (a flatworm or fluke, phylum Platyhelminthes) was noted by Taylor (1987) in populations of Koster's springsnail at Sago Spring on the Refuge. Digenetic trematodes (trematodes in the order Digenera) are parasitic and have the most complicated life histories in the animal kingdom involving two to four intermediate (vertebrate and/or invertebrate) hosts (Hickman et al. 1974). The first larval stage of the trematode nearly always uses a mollusk (snail or bivalve) as the first intermediate host (Hickman et al. 1974). Larval trematode parasites reduce or completely inhibit snail reproduction through castration (Minchella et al.1985). The effect of the trematodes on the springsnail population is not known (USFWS, 2010).

Stressor: Population Dynamics (USFWS, 2010)
Exposure:
Response:
Consequence: Exctinction
Narrative: Several biological traits have been identified as putting a species at risk of extinction (McKinney 1997, O'Grady et al. 2004). Some of these characteristics include having a localized range, limited mobility, and fragmented habitat (Noss et al. 2006, Fagan et al. 2002). The four invertebrate species each have all of these characteristics. Having a small, localized range means that any perturbation (e.g., drought, water contamination) can eliminate the species. Having a high number of individuals at a site provides no protection against extinction. Noel (1954) noted that Noel's amphipod in Lander Spring, New Mexico was the most abundant animal present when she did her research. The species was extirpated from that site when the spring dried up (Cole 1985). Extremely limited dispersal capability effectively eliminated the ability of the amphipod to find and disperse to other suitable habitats or to move out of habitat that becomes unsuitable. Consequently, the amphipod and snails are unable to avoid pollution or other unfavorable changes to their habitat. Severe drought or wildfire, groundwater pollution and spring contamination, or spring development (impoundment, dredging, piping) could result in the extirpation or extinction of the species (USFWS, 2010).

Stressor: Climate Change (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Increased air temperatures lead to higher evaporation rates, which may reduce the amount of runoff, groundwater recharge, and consequently spring discharge. Increased temperatures across the southwest may also increase the extent of area influenced by drought (Lenart 2003), decreasing groundwater recharge regionally, thereby reducing spring discharge.

Prolonged drought leading to diminishment or drying of the spring would have a negative impact on the four invertebrates. Springs would not have to dry out completely to have an adverse effect. Decreased spring flow could lead to a decrease in the amount of suitable habitat, increased water temperature fluctuations, lower dissolved oxygen levels, and an increase in salinity (MacRae et al. 2001). In addition, as water becomes increasingly scarce, conflict over its use becomes more intense. Human and cattle consumption of water would be expected to increase during drought. Any of these factors, alone or in combination, could lead to either the reduction or extirpation of the populations. Thus, climate change is a significant threat to these four invertebrate species into the foreseeable future (USFWS, 2010).

Recovery

Reclassification Criteria:
1: Maintain the presence of each species in the occupied Management Units (MUs) as of the start of this plan, with a stable or increasing average trend in density over 10 years at currently monitored MUs (MUs 1 and 3) (USFWS, 2018).

2: Develop, implement, and fulfill a water management plan, supported by the local irrigation district and other partners, that ensures adequate surface and groundwater levels to 1) sustain downlisting criteria measured by Criterion 1 above, and 2) meet or exceed BLNWR's minimum federally reserved water right flow (0.0042 m3 /s (0.15 cfs)) for 10 years (USFWS, 2018).

3a: Long-term commitments are in place and will continue to maintain sufficient water quality protections over at least 10 years, and water quality sustains each species as measured by Criterion 1 above (USFWS, 2018).

3b: Long-term commitments are in place that would specifically address the four invertebrates and reduce the risk of a catastrophic spill occurring within a drainage or recharge area occupied by any of the four invertebrates over 10 years (USFWS, 2018).

4: A habitat management plan is developed and implemented that ensures that the environment remains as suitable habitat that sustains each species for 10 years (USFWS, 2018).

Delisting Criteria:
1: Maintain the presence of each species in the occupied MUs as of the start of this plan, with a stable or increasing average trend in density over 20 years in MUs 1 and 3 (USFWS, 2018).

2: Develop, implement, and fulfill a water management plan, supported by the local irrigation district and other partners, that ensures adequate surface and groundwater levels to 1) sustain delisting criteria measured by Criterion 1 above, and 2) ensure that the flows in Bitter Creek as measured at the Bitter Creek Flume are greater than 0.007 m3 /s (0.25 cfs) for an additional 10 years (USFWS, 2018).

3a: Long-term commitments are in place and will continue to maintain sufficient water quality protections over at least 20 years, and water quality sustains each species as measured by Criterion 1 above (USFWS, 2018).

3b: Long-term commitments are in place that would specifically address the four invertebrates and reduce the risk of a catastrophic spill occurring within a drainage or recharge area occupied by any of the four invertebrates over 20 years (USFWS, 2018).

4: A habitat management plan is developed and implemented that ensures that the environment remains as suitable habitat that sustains each species for 20 years (USFWS, 2018).

Recovery Actions:

- The actions needed to meet recovery criteria are organized below into six categories that are ranked in order of urgency: 1) ensure adequate water quantity, 2) protect and improve water quality, 3) protect and restore surface habitat, 4) design a long term monitoring strategy that will then become the post delisting monitoring plan, and 5) establish emergency captive rearing programs. These rankings are primarily based on our assessment of the scope, magnitude, and imminence of the threats impacting the four invertebrate species. Actions that address threats of higher magnitude and scope are considered more urgent compared to other actions. While this ranking will guide where we proactively focus our attention in the recovery process, it does not imply that these actions are restricted to being completed in this particular order. For example, 51 opportunities to address lower priority tasks will be considered if they arise before higher priority actions are completed (USFWS, 2018).

Conservation Measures and Best Management Practices:

- Develop a recovery plan for these species. The State of New Mexico has a recovery plan that has helped guide conservation efforts; however, a recovery plan with measurable objectives and criteria needs to be developed by the Service to provide delisting goals (USFWS, 2010).
- Continue investigation of Noel's amphipod population genetics to determine the species' status on the Refuge (USFWS, 2010).
- Continue investigation of the effects of fire on the Pecos assiminea to determine methods of burning an occupied area while protecting the population (USFWS, 2010).
- Secure conservation on additional lands surrounding occupied habitat to protect water quality and improve land management practices (USFWS, 2010).
- Continue to manage Refuge lands to reduce invasive plants (USFWS, 2010).

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SPECIES ACCOUNT: *Lanx sp.* (Banbury Springs limpet)

Species Taxonomic and Listing Information

Listing Status: Endangered; Pacific Region (R1) (USFWS, 2016)

Physical Description

The Banbury Springs lanx (Lanx sp.) was first discovered in 1988 by Terrence Frest. Its conical, pyramid-shaped shell is red-cinnamon in color, ranges from .09 to .28 inch long, and is only .03 to .17 inch tall. The species lacks specialized respiratory organs and is particularly sensitive to dissolved oxygen fluctuations (USFWS, 2016)

Current Range

The Banbury Springs lanx is currently known to only exist in four coldwater spring complexes along 10 river kilometers (rkm) 6 river miles (rm) of the middle Snake River: Thousand Springs, Box Canyon Springs, Banbury Springs, and Briggs Springs. No information on demographics or demographic trend data was found for the Banbury Springs lanx (USFWS, 2016).

Critical Habitat Designated

Yes;

Life History

Spatial Arrangements of the Population

Adult: Clumped (USFWS, 2016)

Environmental Specificity

Adult: Very narrow/Specialist (USFWS, 2016)

Habitat Narrative

Adult: The Banbury Springs lanx requires cold, clear and well-oxygenated water with swift currents. Lanx are found on smooth basalt, boulders, or cobble-sized grounds ranging from 2 to 20 inches deep, but they avoid areas with green algae. Currently this species only exists at four cold-spring locations that are isolated from each other: Thousand Springs, Box Canyon Springs, Briggs Springs and Banbury Springs (USFWS, 2016).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2016)

Dispersal

Adult: Low (USFWS, 2016)

Dispersal/Migration Narrative

Adult: All lanx colonies are isolated from each other and restricted to their present locations, resulting in no possible conduit for natural dispersal or range expansion (USFWS 2006b, p. 7) (USFWS, 2016).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Number of Populations:

4 (USFWS, 2016)

Population Narrative:

Since limpets can only respire through their mantle, they are susceptible to flucuations in dissolved oxygen levels. Preliminary genetic work is underway and initial results indicate it is a distinct taxon (although more closely related to <i>Fisherola </i>than <i>Lanx</i>) (USFWS, 2006). Decline of <30% to increase of 25% At Thousand Springs, average population density was between 16 and 48 individuals per square m and total number of individuals was estimated between 600 and 1200 (Frest and Johannes, 1992); also service personnel found 9 individuals while visually inspecting 40 cobbles in January 2006 (USFWS, 2007). In Box Canyon at least 7 surveys have been conducted and was found in 1 of 17 sites surveyed in 1989 and found again at the same site (just upstream of Sculpin Pool) in 2006 (32 individuals in 82 cobbles inspected) (USFWS, 2006). Nine surveys have been conducted at Banbury Springs and it has only been found in the lower portion of the easternmost spring flowing into Morgan Lake repeatedly (1995, 1996, 2000, 2001, 2002, 2003) (USFWS, 2007). Two surveys have been conducted on Briggs Springs with the species described as common in 1994 (6 or more individuals per cobble) and 4.7 per cobble in 2006 (USFWS, 2006). It is currently known to only exist in four coldwater spring complexes along 10 river km of the middle Snake River: Thousand Springs, Box Canyon Springs, Banbury Springs, and Briggs Springs (USFWS, 2006). (NatureServe, 2015). The population size, abundance, and trends of the Banbury Springs lanx are largely uncertain as little density and trend information exists. Very few density estimates have been made and methods have not been consistent between studies (USFWS, 2016).

Threats and Stressors

Stressor: Habitat modification (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat/habitat degradation
Narrative: Habitat modification is listed as a threat to this species. Habitat modification has affected this species by reducing the availability of suitable coldwater spring habitats. Examples of habitat modification at the four known locations include: hydroelectric development in the Thousand Springs Preserve; aquaculture diversions in Box Canyon and Briggs Springs; and past impoundments of the springflows at Banbury Springs (USFWS, 2016).

Stressor: Spring flow reduction (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat/habitat degradation
Narrative: Spring flow reduction is listed as a threat to this species. Coldwater springflows from the Snake River aquifer at the four Banbury Springs lanx populations are also declining. As spring

flows continue to decline throughout the range of this species, flows appropriated for hydroelectric power generating facilities and coldwater springflows diverted for aquaculture facilities and other uses will continue to compete for and likely reduce the available water for the Banbury Springs lanx (USFWS, 2016).

Stressor: Reduced groundwater quality (USFWS, 2016)
Exposure:
Response:
Consequence: Habitat degradation
Narrative: Reduced groundwater quality is listed as a threat to this species. Degraded groundwater quality of the Snake River aquifer will continue to affect the coldwater spring outflows upon which this species exists (USFWS, 2016).

Stressor: Inadequate regulatory mechanisms (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat/Extinction
Narrative: inadequate regulatory mechanisms are listed as a threat to this species. Existing regulatory mechanisms that oversee groundwater management of the Snake River Plain Aquifer may not be adequate to reverse the declining coldwater spring outflows upon which the Banbury Springs lanx depends (USFWS, 2016).

Recovery

Reclassification Criteria:
Reclassification Criteria: 1: Maintain the presence of each species in the occupied Management Units (MUs) as of the start of this plan, with a stable or increasing average trend in density over 10 years at currently monitored MUs (MUs 1 and 3) (USFWS, 2018). 2: Develop, implement, and fulfill a water management plan, supported by the local irrigation district and other partners, that ensures adequate surface and groundwater levels to 1) sustain downlisting criteria measured by Criterion 1 above, and 2) meet or exceed BLNWR's minimum federally reserved water right flow (0.0042 m3 /s (0.15 cfs)) for 10 years (USFWS, 2018). 3a: Long-term commitments are in place and will continue to maintain sufficient water quality protections over at least 10 years, and water quality sustains each species as measured by Criterion 1 above (USFWS, 2018). 3b: Long-term commitments are in place that would specifically address the four invertebrates and reduce the risk of a catastrophic spill occurring within a drainage or recharge area occupied by any of the four invertebrates over 10 years (USFWS, 2018). 4: A habitat management plan is developed and implemented that ensures that the environment remains as suitable habitat that sustains each species for 10 years (USFWS, 2018).

Revising the Recovery Priority Number from 5C to 4C (USFWS, 2018a).

Delisting Criteria:
1: Maintain the presence of each species in the occupied MUs as of the start of this plan, with a stable or increasing average trend in density over 20 years in MUs 1 and 3 (USFWS, 2018). 2: Develop, implement, and fulfill a water management plan, supported by the local irrigation district and other partners, that ensures adequate surface and groundwater levels to 1) sustain delisting criteria measured by Criterion 1 above, and 2) ensure that the flows in Bitter Creek as

measured at the Bitter Creek Flume are greater than 0.007 m3 /s (0.25 cfs) for an additional 10 years (USFWS, 2018). 3a: Long-term commitments are in place and will continue to maintain sufficient water quality protections over at least 20 years, and water quality sustains each species as measured by Criterion 1 above (USFWS, 2018). 3b: Long-term commitments are in place that would specifically address the four invertebrates and reduce the risk of a catastrophic spill occurring within a drainage or recharge area occupied by any of the four invertebrates over 20 years (USFWS, 2018). 4: A habitat management plan is developed and implemented that ensures that the environment remains as suitable habitat that sustains each species for 20 years (USFWS, 2018).

Recovery Actions:

- Ensure water quality standards for cold-water biota and habitat conditions so that viable, self-reproducing snail colonies are established in free-flowing mainstem and cold-water spring habitats within specified geographic ranges, or recovery areas, for each of the S species. Snails detected at the sites selected for monitoring will be surveyed on an annual basis to determine population stability and persistence, and verify presence of all life history stages fora minimum of 5 years.
- Develop and implement habitat management plans that include conservation measures to protect cold-water spring habitats occupied by Banbury Springs lanx, Bliss Rapids snail, and Utah valvata snail from further habitat degradation (i.e. diversions, pollution, development) as described in Action #1.
- Stabilize the Snake River Plain aquifer to protect discharge at levels necessary to conserve the listed species cold-water spring habitats.
- Evaluate the effects of non-native flora and fauna on listed species in the Snake River from Ci. Strike Dam to American Falls Dam

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Revise Taxonomy in List of Endangered and Threatened Wildlife While the Banbury Springs limpet is currently described as Idaholanx fresti (Campbell et al. 2017), it is still considered Lanx sp. (undescribed) under the List of Endangered and Threatened Wildlife in title 50 of the Code of Federal Regulations (50 CFR 17.11(h)). Therefore we recommend revising the List of Endangered and Threatened Wildlife to reflect its current description as Idaholanx fresti. Revise Recovery Plan We continue to recommend that the Snake River Aquatic Species Recovery Plan be updated and/or revised to include new information about the species and its threats that we have learned since the plan was completed in 1995 (see Section 2.2.3). Monitoring We recommend continued annual monitoring of the species in the 4 occupied spring complexes occupied by the Banbury Springs limpet. While this information is needed to assess the recovery status of the species, it also allows us to continually assess the need of other conservation actions, such as macrophyte control and translocation. In addition, we recommend more frequent monitoring of water quality and quantity at the 4 spring complexes. We also recommend implementing monitoring of macrophyte presence and trends at the 4 spring complexes to investigate whether macrophytes are increasing and further limiting suitable habitat availability for the species. Continue Macrophyte Control as Needed Based on past success, we have continued to implement macrophyte control measures at selected springs to increase suitable habitat for the species. These efforts have contributed to increasing density findings, along with providing additional habitat availability. We recommend continued macrophyte removal measures as needed. Consider Future Translocations as Needed In 2016, we translocated 19 individual Banbury Springs limpets into Thousand Springs from Banbury Springs. This effort, in conjunction with macrophyte control, likely led to an increased density finding for this population in 2017. Give this, we recommend implementing additional translocations as needed in the future. In addition, we also recommend serious consideration of translocating the species into protected coldwater spring habitats not occupied by the species. Captive Propagation Program We have initiated development of a captive propagation program plan for the species at the Hagerman National Fish Hatchery, in Hagerman, Idaho. The objectives of this effort are to provide Banbury Springs limpets in a controlled environment to carry out needed life history and genetic investigations (a recommendation in the 2006 5-Year Status Review; USFWS 2006, p. 21) and other needed research on the species. In addition, having a propagation program in place would also allow for re-establishment of wild populations should they become extirpated, help ensure we maintain genetic representation from each of the 4 populations, and allow for the establishment of other populations in appropriate, unoccupied habitats. We recommend continuing working with the State of Idaho Department of Fish Game, who is scheduled to take over day-to-day management activities of the Hagerman National Fish Hatchery from the USFWS starting in October 2018 (Spokesman Review in litt. 2018). Collaborative Conservation Effort for the Eastern Snake Plain Aquifer Consider developing a collaborative effort with strategic partners towards conservation of springs occupied by the Banbury Springs limpet. For example, utilize the Banbury Springs limpet and co-occurring threatened Bliss Rapids snail as “canaries in the coal mine” to help monitor the overall health of the Eastern Snake Plain Aquifer (USFWS, 2018).

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SPECIES ACCOUNT: *Leptoxis ampla* (Round rocksnail)

Species Taxonomic and Listing Information

Listing Status: Threatened; October 28, 1998; Southeast region (R4)

Physical Description

The round rocksnail is a pleurocerid snail that grows to about 20 mm (0.8 in) in length. The shell is subglobose, with an ovately rounded aperture. The body whorl is shouldered at the suture, and may be ornamented with folds or plicae. Color may be yellow, dark brown, or olive green, usually with four entire or broken bands (Goodrich 1922) (USFWS, 2005).

Taxonomy

Dillon and Lydeard (1998) found low levels of genetic divergence among populations of Leptoxis picta, Leptoxis ampla, and Leptoxis taeniata and referred to these three taxa as "the Leptoxis picta group" but noted further study is warranted. In a preliminary analysis of molecular phylogeny of Mobile River basin pleurocerids, Lydeard et al. (1997) concluded that Leptoxis picta and Leptoxis plicata are quite distinct from one another and all other pleurocerids studied while Leptoxis taeniata and Leptoxis ampla sister taxa and Leptoxis picta the most basal of the group (NatureServe, 2015).

Historical Range

The round rocksnail was historically found in the Cahaba River and the Little Cahaba River, Bibb County, Alabama; and the Coosa River, Elmore County, and tributaries—Big Canoe and Kelly's creeks, St. Clair County; Ohatchee Creek, Calhoun County; Yellowleaf Creek, Shelby County; and Waxahatchee Creek, Shelby/Chilton counties, Alabama (Goodrich, 1922) (USFWS, 2005).

Current Range

The round rocksnail is currently known from a shoal series in the Cahaba River, Bibb and Shelby counties, Alabama, and from the lower reach of the Little Cahaba River, and the lower reaches of Shade and Six-mile creeks in Bibb County, Alabama (Bogan and Pierson, 1993b) (NatureServe, 2015).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Unknown

Reproduction Narrative

Adult: Adult rocksnails move very little, and females probably glue their eggs to stones in the same habitat (Goodrich, 1922). Longevity in the round rocksnail is unknown; however, Heller (1990) reported a short life span (less than 2 years) in a Tennessee River rocksnail (USFWS, 2005).

Spatial Arrangements of the Population

Adult: Clumped (inferred from USFWS, 2005 and NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (inferred from USFWS, 2005 and NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2005 and NatureServe, 2015)

Site Fidelity

Adult: High (inferred from USFWS, 2005 and NatureServe, 2015)

Habitat Narrative

Adult: Rocksnails are gill breathing snails found attached to cobble, gravel, or other hard substrates in the strong currents of riffles and shoals (USFWS, 2005; NatureServe, 2015). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 2005; NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Dispersal

Adult: Low (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Immigration/Emigration

Adult: Unlikely (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Low mobility/motility and dispersal are inferred based on taxa and habitat information as are non-migratory and low dispersal status (USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Population Information and Trends

Population Trends:

Decreasing (Natureserve, 2015)

Resiliency:

Low (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Representation:

Low (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Redundancy:

Low (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Population Growth Rate:
Declining (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Number of Populations:
6 to 20 (NatureServe, 2015)

Population Size:
250 - 10,000 (NatureServe, 2015)

Adaptability:
Low (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015)

Population Narrative:
NatureServe (2015) notes that both long-term and short term population trends are decreasing. In addition NatureServe notes that there are 6 - 20 populations and that populations are estimated at between 250 and 10,000 individuals. Resiliency, redundancy, representation and adaptability are inferred based on limited distribution and specific habitat needs as well as taxonomy (inferred from USFWS, 2005; USFWS, 2006 and NatureServe, 2015).

Threats and Stressors

Stressor: Impoundments (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Dams change such areas by eliminating or reducing currents, and allowing sediments to accumulate on inundated channel habitats. Impounded waters also experience changes in water chemistry which could affect survival or reproduction of riverine snails. For example, many reservoirs in the Basin currently experience eutrophic (enrichment of a water body with nutrients) conditions and chronically low dissolved oxygen levels (Alabama Department of Environmental Management [ADEM], 1994, 1996). Such physical and chemical changes can affect feeding, respiration, and reproduction of these riffle and shoal snail species. In addition to directly altering snail habitats, dams and their impounded waters also formed barriers to the movement of snails that continued to live below dams or in unimpounded tributaries. It is suspected that many such isolated colonies gradually disappear as a result of local water and habitat quality changes. Unable to emigrate (move out of the area), the isolated snail populations are vulnerable to local discharges as well as any detrimental land surface runoff within their watersheds. Although many watershed impacts have been temporary, eventually improving or even disappearing with the advent of new technology, management practices, or laws, dams and their impounded waters prevent natural recolonization by snail populations surviving elsewhere (USFWS, 2005).

Stressor: Water pollution (USFWS, 2005)
Exposure:
Response:
Consequence:

Narrative: Short-term and long-term impacts of point and nonpoint source water and habitat gradation continue to be a primary concern for the survival of all these snails, compounded by their isolation and localization. Point source discharges and land surface runoff (nonpoint pollution) can cause nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that are likely to seriously impact aquatic snails. Point sources of water quality degradation include municipal and industrial effluents. Nonpoint source pollution from land surface runoff can originate from virtually all land use activities, and may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and oils and greases (ADEM, 1996). During recent surveys for these snails, sediment deposition and/or dense algal mats (a sign of nutrient pollution of streams) were noted at many historic collection localities where snails had disappeared (Bogan and Pierson, 1993a, 1993b; Hartfield, 1991; Service Field Observations, 1992-1994, Jackson Field Office, MS) (USFWS, 2005).

Stressor: Sedimentation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Excessive sediments are believed to impact riverine snails requiring clean, hard shoal stream and river bottoms, by making the habitat unsuitable for feeding or reproduction. Similar impacts resulting from sediments have been noted for many other components of aquatic communities. For example, sediments have been shown to abrade and/or suffocate periphyton (organisms attached to underwater surfaces, upon which snails may feed); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters, 1995). Sediment is the most abundant pollutant produced in the Basin (ADEM, 1989). Potential sediment sources within a watershed include virtually all activities that disturb the land surface, and all localities currently occupied by these snails are affected to varying degrees by sedimentation. The amount and impact of sedimentation on snail habitats may be locally correlated with the land use practice, and the degree of implementation of agriculture, forestry, and construction Best Management Practices (USFWS, 2005).

Stressor: Runoff (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Land surface runoff contributes the majority of nutrients to streams in the Mobile River Basin (Atkins et al., 2004). Excessive nutrient input (from fertilizers, sewage waste, animal manure, etc.) can result in periodic low dissolved oxygen levels that are detrimental to aquatic species (Hynes, 1970). Nutrients also promote heavy algal growth that may cover and eliminate clean rock or gravel habitats of shoal dwelling snails. Nutrient and sediment pollution may have synergistic effects (a condition in which the toxic effect of two or more pollutants is much greater than the sum of the effects of the pollutants when operating individually) on freshwater snails and their habitats, as has been suggested for aquatic insects (Waters, 1995) (USFWS, 2005).

Stressor: Waste water treatment (USFWS, 2005)
Exposure:
Response:

Consequence:
Narrative: The cylindrical lioplax, flat pebblesnail, and the round rocksnail currently survive in localized reaches of the Cahaba River drainage. Water quality studies in the upper Cahaba River drainage by the Geological Survey of Alabama (Shepard et al., 1996) found that discharges from 34 waste water treatment plants (WWTPs) in the upper drainage have contributed to water quality impairment. This was reflected by low levels of dissolved oxygen downstream of Birmingham; ammonia and chlorination by-products in excess of recommended water quality criteria; and eutrophication (demonstrated by dense algal mats and nightly sags in dissolved oxygen levels) due to excessive levels of phosphorus and nitrogen. The study noted that these problems are chronic and have been a factor in a loss of mollusk and fish diversity throughout the drainage. Their results indicate that the upper Cahaba River drainage is primarily impacted by nonpoint runoff and WWTPs through physical habitat destruction by sedimentation, and chronic stress from exposure to toxics and low dissolved oxygen. The middle Cahaba River is primarily impacted by eutrophication and associated effects (USFWS, 2005).

Stressor: Predation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Aquatic snails are consumed by various vertebrate predators, including fishes, mammals, and possibly birds. Predation by naturally occurring predators is a normal aspect of the population dynamics of a species and is not considered a threat to these species. However, the potential now exists for black carp (Mylopharyngodon piceus), a nonselective snail eating fish recently introduced into waters of the United States, to eventually enter the Mobile River Basin. Exotic black carp escaped to the Osage River in Missouri when hatchery ponds were flooded during a 1994 spring flood of the river (LMRCC newsletter, 1994). Although black carp have been banned for use in aquaculture in the State of Alabama, they are cultured and sold within the State of Mississippi (D. Reike, Mississippi Department of Wildlife, Fisheries, and Parks, pers. comm., 1997). The extent of stocking black carp for snail control in aquaculture ponds within the Basin is currently unknown (USFWS, 2005).

Recovery

Delisting Criteria:
1. A minimum of 3 natural or re-established populations have been shown to be persistent (i.e., stable or increasing) for a period of 10 years (2 to 5 generations) (USFWS, 2005).

2. There are no apparent or immediate threats to the populations (see Listing/Recovery Factor Criteria, below). A population is defined as all snails occurring within a contiguous river or stream reach extending a minimum of 30 km (18 mi). Snails in a recovered population should be easily found in appropriate habitat throughout the occupied reach (USFWS, 2005).

Recovery Actions:
- The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin. The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S.

Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin (USFWS, 2005).

- 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control. 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. 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All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control (USFWS, 2005).

- 2. Consider options for free-flowing river and stream mitigation strategies that give high priority to avoidance and restoration. As noted above, avoidance of impact is the most important and immediate management need for maintaining existing imperiled populations and their habitats. However, long-term management requires the ability to accommodate changes in human use of the Basin's resources. Restoration of stream and river reaches, and rehabilitation of their aquatic communities will increase management options to accommodate future changes within the Basin. Compensating for aquatic habitat impacts can be an important component of aquatic habitat management. 2.l Identify appropriate mitigation measures for free flowing streams and rivers. When destruction or alteration of stream or river habitat is unavoidable, there should be an effort to restore or rehabilitate a comparable amount of instream aquatic habitat elsewhere in the Basin. Unfortunately, there is little guidance or consensus for the amount and degree of measures that could satisfy mitigation goals for free flowing riverine habitat. Federal, State, and local environmental and regulatory agencies and nongovernmental interests must work toward consensus on this problem, considering issues such as amount, quality, and location of river or stream segments under consideration for mitigation measures, and other alternatives, such as the need and possibility of establishing mitigation banks for permit applicants. 2.11 Investigate the potential of partnerships and assistance to relieve land use problems within watersheds as a form of mitigation. Concentrated land uses within watersheds can overwhelm the benefits of individual landowner Best Management Practices (BMPs). Animal wastes from concentrated husbandry of poultry, fish, and livestock is a major determinant of water quality in some watersheds. Urbanization of watersheds also causes complex runoff/water quality problems. Such problem areas may offer creative mitigation opportunities. Examples include developing equipment, facilities, or other components to establish centralized waste treatment for areas of high concentration of poultry farms and other animal feedlots; and providing assistance to communities for stormwater catchment and treatment (USFWS, 2005).
- 3. Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use. BMPs can be effective and practical actions identified to prevent or reduce nonpoint pollution from specific land use activities (ADEM, 1989). For example, agricultural BMPs are designed to reduce sediments, animal wastes,

fertilizers, and pesticides in stormwater runoff (e.g., Alabama Soil and Water Conservation Committee (ASWCC), 1995). Mining BMPs address sediments and water quality parameters such as acidity and metal concentrations (e.g., ADEM, 1989). Silviculture BMPs include actions to minimize sediments, nutrients, organics, chemicals, and stream canopy removal (e.g., Alabama Forestry Commission, 1993). BMPs are also available for urban, construction, and homeowner activities that address stormwater runoff quality and quantity (ASWCC, 1992, MSDEQ, 1994). BMPs are developed by State and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and State resource agencies should continue to promote and improve BMPs when necessary as a nonregulatory approach to aquatic ecosystem management. 3.1 Work with State and private partners to promote land and water stewardship awareness. Local offices of State and Federal agencies and private organizations can become a primary source of encouragement and information for imperiled species and aquatic ecosystem management. For example, local offices (e.g, Soil and Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commissions, private industry groups, environmental groups, etc.) can identify watersheds with listed species within their areas; inform local landowners of listed species' presence, needs, and special management concerns; recommend appropriate BMPs; and mediate landowner concerns or conflicts with appropriate State and/or Federal agencies. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity. Private industry groups can work with local landowners to customize BMPs where needed to address watershed problems and practices. 3.2 Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers in the Basin. Properly designed SMZs, which act as filter strips, can buffer the impacts of land use activities on water and stream bottom habitat quality. SMZs protect public and private property from erosion, reduce downstream sedimentation, and enhance fish and wildlife values for both game and nongame species. SMZs can also reduce nutrient levels in tributary streams in the Basin, which will help control eutrophication in Basin reservoirs (see Part I, Section C in Ecosystem Recovery Plan). Some farmlands adjacent to streams and rivers may qualify for SMZ set aside under the U.S. Department of Agriculture's Conservation Reserve Program and other initiatives. SMZs are widely recognized as cost effective habitat management practices. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. SMZs may be custom designed to protect stream habitat while achieving individual landowners management objectives. For example, the Natural Resources Conservation Service recommends SMZs from 22 to 91 meters (75 to 300 feet), with varying restrictions, depending on soil, slope, topography, and land use. Other government agencies and private groups make similar recommendations. SMZs are also effective in controlling urban and suburban stormwater runoff (USFWS, 2005).

- 4. Encourage and support community based watershed stewardship planning and action. Protection, restoration, and management planning for imperiled aquatic habitats is best accomplished by partners and stakeholders within a watershed. Such grassroots community planning educates participants about aquatic species, their habitat needs, and sensitivities; acknowledges local activities, problems and their effects on water; and leads to consensus based local solutions. Stewardship partnerships are essential in watersheds supporting listed or other imperiled aquatic species, and should be encouraged within any of the Basin's watersheds. Resource and regulatory agencies should offer support, materials, and technical and facilitation assistance when requested. 4.1 Reduce private land use/endangered species conflicts. Landowners and other watershed residents may feel threatened by the presence of listed aquatic species, and be reluctant to participate in watershed stewardship planning or action. In such cases, Watershed Habitat Conservation Plans, Safe Harbor Agreements, or other innovative avenues to assure and guarantee private land uses within watersheds should be developed (USFWS, 2005).

- 5. Develop and implement programs to educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship. Only an informed and proactive public can bring about ecosystem stabilization and rehabilitation. Successful ecosystem management will require public involvement, monitoring, and commitment of resources. Educational materials and programs should describe the concept and need for ecosystem management, its long-term economic and environmental advantages, and public and individual stewardship responsibilities (USFWS, 2005).
- 6. Conduct basic research on endemic aquatic species and apply the results toward management and protection of aquatic communities. The biology and ecology of endemic aquatic species in the Basin are poorly known. Information on distribution, habitat requirements, life stage sensitivity to contaminants, and the identification of mussel host fish is essential to the recovery of endemic species and management and protection of their communities and habitats. All partners should be aware of research efforts and results, so that information can be immediately applied. 6.1 Survey and monitor the status of listed and other endemic aquatic species. Extant populations of listed and other endemic species should be located and their status monitored. 6.2 Conduct detailed physical and molecular genetic analyses of endemic species. Most of the Basin's endemic aquatic species have not been fully described anatomically. This information, in conjunction with genetic biochemical comparisons of populations and related species, may provide information important to population management and recovery. 6.3 Determine contaminant sensitivity for each life stage. It is known that juvenile and adult life stages of aquatic fauna may differ in sensitivity to contaminants. The technology and methodology should be developed to determine sub-lethal and lethal levels of pesticides, herbicides, and common contaminants and discharges to listed species and other endemic organisms in the Basin. 6.4 Conduct life history research on endemic species to include reproduction, food habits, age and growth, mortality factors. etc. Life history information may provide insight into past declines, current status of endemic species, weak links in the life cycle, and management guidance for their recovery. 6.41 Determine nutritional requirements of endemic species life stages. It is possible that juvenile forms of many taxa feed on different items than adults. Such requirements may be limiting factors in the survival of these species. Nutritional requirements must be known for successful captive propagation of endemic species (see Task 7) (USFWS, 2005).
- 7. Develop and implement technology for maintaining and propagating endemic species in captivity. Populations of endemic species in the Basin are isolated by large expanses of impounded, or otherwise severely altered, habitat. Maintenance of genetic flow between extant populations, and reintroduction of species to restored habitats, will require human intervention. Populations of many species are currently too low to justify translocation of wild stock between drainages. Captive propagation will be required to produce reintroduction stock if ecosystem restoration is eventually successful (see Task 8). Large numbers of juveniles and adults will also be needed for research to determine sensitivity of species to common contaminants (Task 6.3) (USFWS, 2005).

- 8. Reintroduce aquatic species into restored habitats, as appropriate. For many listed species, this step will be possible only when, and if, successful captive propagation technology is developed. Reintroduction will be closely coordinated with appropriate State agencies and affected private landowners. No reintroduction or translocation of species should be made without the concurrence of the appropriate State wildlife resource agencies and the knowledge and consensus of local watershed residents. 8.1 Identify sites for translocation/reintroduction. Potential sites for reintroduction consist of streams within the historic range of endemic species that meet the substrate, flow, water quality, and other environmental requirements of the species. Such sites need to be identified and monitored. 8.11 Survey and prioritize potential sites. Water quality, substrate composition, aquatic community composition, and watershed land uses should be characterized. Priority should be given to watersheds with appropriate habitat, diverse faunal assemblages, minimal land use impacts, and active management programs. 8.2 Translocate target endemic species to priority sites. Translocations should be conducted in a rigorous, scientific manner, and should be well-documented. 8.3 Monitor translocated populations. Stream and river reaches with translocated populations should be monitored and surveyed annually for a minimum of 10 years following translocation (USFWS, 2005)..
- 9. Monitor listed species population levels and distribution and periodically review ecosystem management strategy. Listed species will be monitored by Tasks 6.1 and 8.3. Changes in distribution (losses and gains) should be used to focus recovery efforts and priorities. Ecosystem management strategy should be periodically reviewed and revised, if appropriate, based on this information (USFWS, 2005).
- 10. Coordinate ecosystem management actions. The above recovery tasks approach ecosystem stabilization and management on three tiers: Federal and State regulatory authority and responsibility; private activities, public education and involvement; and research. Implementation of these tasks will involve multiple partners including State and Federal agencies, municipal and county governments, environmental and recreational organizations, civic groups, educational and research institutions, business and industry groups, landowners, and interested individuals. Successful implementation requires development of partnerships, coordination of on-going activities, determination and prioritization of needed actions, and monitoring recovery progress within each of the Basin's major drainages (USFWS, 2005).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS: • Conduct systematic population monitoring of extant and reintroduced populations of these snails and document potential threats to those populations. • Evaluate the status of the lacy elimia in Emauhee and Weewoka Creeks and confirm that its status in Cheaha Creek remains stable. Also conduct surveys within the Middle Coosa River tributaries that are within the historic range of the species. Results from these studies may suggest a need to upgrade its ESA status from threatened to endangered. • Continue to evaluate the extent and viability of the new populations of cylindrical lioplax within the Little Cahaba River, Yellowleaf Creek, and Choccolocco Creek, in order to determine if it meets the recovery criteria for downlisting to threatened. • Reassess and amend as needed the recovery plan for 6 Mobile River Basin aquatic snails, specifically, the recovery criteria and population criteria for recovery should be evaluated. • Continue to develop and implement habitat restoration plans for the streams where these species occur, or where they can be reintroduced. • Continue assisting the State’s propagation studies and efforts. • Work with State agencies, local groups, and individuals to protect and improve water quality in the drainages supporting the six snail species. • Implement all other recovery tasks (USFWS, 2016).

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USFWS. 2016. Cylindrical Lioplax (Lioplax cyclostomaformis) Flat Pebblesnail (Lepyrium showalteri) Plicate Rocksnail (Leptoxis plicata) Painted Rocksnail (Leptoxis taeniata) Round Rocksnail (Leptoxis ampla) Lacy Elimia (Elimia crenatella) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office.

SPECIES ACCOUNT: *Leptoxis foremani* (Interrupted (=Georgia) Rocksnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2010; Southeast Region (R4)

Physical Description

The interrupted rocksnail (Leptoxis foremani) is a small-to-medium-sized freshwater snail that historically occurred in the Coosa River drainage of Alabama and Georgia. The shell grows to approximately 22 mm (1 in) in length and may be ornamented by partial costae (folds in the surface). The shell is subglobose (not quite spherical), thick, dark brown to olive in color, occasionally spotted, and generally covered with fine striae (small ridges extending around the whorls). The spire (apex) of the shell is very low, and the aperture (opening) is large and subrotund (not quite round) and covered with an operculum when the snail withdraws into the shell (Figure 3) (USFWS, 2014).

Taxonomy

The interrupted rocksnail, a member of the aquatic snail family Pleuroceridae, was described from the Coosa River, Alabama, by Lea in 1843. Goodrich (1922) placed the species in the "Anculosa (=Leptoxis) picta (Conrad 1834) group," which also included the Georgia rocksnail (Leptoxis downei (Lea 1868)). L. foremani was considered to inhabit the Lower Coosa River, with L. downei inhabiting the Upper Coosa drainage (Goodrich 1922). When a rocksnail population was rediscovered surviving in the Oostanaula River, Georgia, in 1997, it was initially identified as L. downei (Williams and Hughes 1998, Johnson and Evans 2000); however, Burch (1989) had previously placed L. downei within L. foremani as an ecological variant. L. foremani is recognized as the valid name for the interrupted rocksnail (Johnson et al. 2013) (USFWS, 2014).

Historical Range

The interrupted rocksnail was historically found in colonies on reefs and shoals of the Coosa River and several of its tributaries in Alabama and Georgia (Figure 5). The range of the rocksnail formerly encompassed more than 800 km (500 mi) of river and stream channels, including the Coosa River (Coosa, Calhoun, Cherokee, Elmore, Etowah, Shelby, St. Clair, and Talladega Counties), Lower Big Canoe Creek (St. Clair County), and Terrapin Creek (Cherokee County) in Alabama; and the Coosa and Lower Etowah Rivers (Floyd County), the Oostanaula River (Floyd and Gordon Counties), the Coosawattee River (Gordon County), and the Conasauga River (Gordon, Whitfield, and Murray Counties) in Georgia (Goodrich 1922, Johnson 2004, FLMNH in litt. 2006). (USFWS, 2014).

Current Range

Intensive surveys of the Oostanaula, Coosa, Coosawattee, Etowah, and Conasauga Rivers since 1999 have located the species in about 12 km (7.5 mi) of the Oostanaula River upstream of the Gordon–Floyd County line (Johnson and Evans 2000, Johnson and Evans 2001). A captive colony was maintained at the Tennessee Aquarium Research Institute (TNARI) from 2000 through 2005 for study and propagation. In coordination with TNARI and the Service, the Alabama Department of Conservation and Natural Resources (ADCNR) developed a plan and strategy to reintroduce interrupted rocksnails from the TNARI colony into the Coosa River above

Wetumpka, Elmore County, Alabama (ADCNR 2003). Since their reintroduction into the Lower Coosa River of Alabama, a few of the 2003 hatchery-cultured interrupted rocksnails were observed in the vicinity of the release site in 2004 (Johnson in litt. 2005c). An alternative site was selected for release in August 2005, and 18 snails were located 3 months following release (Pierson in litt. 2005) (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 interrupted rocksnail (Leptoxis foremani) (and two other species) under the Endangered Species Act of 1973, as amended (75 FR 67512 - 67550). The critical habitat includes approximately 101 kilometers (km) (63 miles (mi)) of stream and river channels as critical habitat for the interupted rocksnail in Cherokee and Elmore counties in Alabama, and Floyd and Gordon counties in Georgia.

Critical Habitat Designation

Three units are designated as critical habitat for the interrupted rocksnail: IR 1, IR 2, and IR 3. These areas encompass approximately 101 kilometers (km) (63 miles (mi)) of stream and river channels in Cherokee and Elmore counties in Alabama, and Floyd and Gordon counties in Georgia. Critical habitat includes only the stream channel within the ordinary high water line (75 FR 67512 - 67550).

Unit IR 1: Coosa River, Cherokee County, Alabama. Unit 1 for the interrupted rocksnail includes approximately 11 km (7 mi) of the Coosa River extending from Weiss Dam downstream to about 1.6 km (1 mi) below the confluence of Terrapin Creek, Cherokee County, Alabama. The State of Alabama owns navigable stream bottoms within the ordinary high water line, and the Coosa River is considered navigable. The interrupted rocksnail historically inhabited the Coosa River in Cherokee County. Although the species does not currently occupy the area, Unit 1 is essential to the conservation of the interrupted rocksnail due to the high degree of stochastic threats to the single surviving population in the Ostanaula River and the need to re-establish the species within other portions of its historical range. The presence of the endangered southern clubshell, the threatened fine-lined pocketbook, and other mussel and snail species in the Coosa River at and below the confluence of Terrapin Creek indicates the presence of PCEs 1, 2, 3, and 4 for the interrupted rocksnail. 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) currently in progress. These minimum flows will improve the PCEs necessary for the survival of the interrupted rocksnail in about 11 km (7 mi) of the Coosa River, between Weiss Dam downstream to the confluence with Terrapin Creek. Implementation of minimum flows from Weiss Dam (Weiss Bypass Working Group 2005, pp. 6–8) will improve PCEs necessary for the survival of the interrupted rocksnail. The majority of flow into the reach above the confluence of Terrapin Creek originates from Weiss Dam. Therefore, there is little threat of nonpoint source pollution, and reduced potential of stochastic threats such as drought and spills. ADCNR recognizes this reach as having high conservation potential for imperiled mollusks in Alabama and is planning to reintroduce imperiled mollusk species, including the interrupted rocksnail, into the reach following initiation of minimum flows. Re-establishing the interrupted rocksnail into the Coosa River will significantly reduce stochastic threats to the survival of the species and is essential to its conservation.

Unit IR 2: Oostanaula River, Gordon and Floyd Counties, Georgia. Unit 2 for the interrupted rocksnail includes approximately 77 km (48 mi) of the Oostanaula River from the Conasauga–Coosawattee confluence in Gordon County, downstream to Georgia Highway 1 loop in Floyd County, Georgia. The State of Georgia owns navigable stream bottoms within the ordinary high water line, and the Oostanaula River is considered navigable. The interrupted rocksnail occupies shoals along a 12-km (7.4-mi) reach of the Oostanaula River, extending from the confluence of Johns Creek in Gordon and Floyd Counties, downstream to the confluence of Armuchee Creek in Floyd County, Georgia. Threats to the interrupted rocksnail and its habitat in the Oostanaula River that may require special management of the PCEs include the potential of 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 activities such as impoundment, hydropower generation, 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. Although there are no recent collections of the species from shoal habitats above and below the currently inhabited reach, these currently unoccupied areas contain three of the PCEs required by the species, including geomorphically stable stream channels, natural flows, and appropriate substrates (PCEs 1, 2, and 4). The presence of other mollusk species with similar habitat requirements as the interrupted rocksnail in this reach, including the endangered triangular kidneyshell, along with more common species of pleurocerid snails, also indicates the potentially suitable presence of appropriate water quality (PCE 3). Shoals within the 65 km (40.6 mi) of currently unoccupied reaches of the Oostanaula River are available to natural recolonization of the species. Expanding the range of the interrupted rocksnail into adjacent shoals in the river would greatly reduce the degree of threat from stochastic events, and is essential to the conservation of the interrupted rocksnail.

Unit IR 3: Lower Coosa River, Elmore County, Alabama. Unit 3 for the interrupted rocksnail includes 13 km (8 mi) of the Lower Coosa River between Jordan Dam and Alabama Highway 111 in Elmore County, Alabama. The State of Alabama owns navigable stream bottoms within the ordinary high water line, and the Coosa River is considered navigable. The Lower Coosa River is within the historical range of the species, and a small population of the interrupted rocksnail has been reintroduced into a 1-km (0.6-mi) portion of a shoal there (ADCNR 2004, p 33). However, this reintroduced population will likely require augmentations over several years before population size can reach self-sustainable levels. The remaining 12 km (7.4 mi) of this reach, from Jordan Dam downstream to the Fall Line at Wetumpka, contains numerous highquality shoals and pools characteristic of the large river habitats historically occupied by the species. Several other species of pleurocerid snails, the endangered tulotoma snail, and a diverse mussel fauna are currently found throughout the reach, indicating the presence and suitability of PCEs 1, 2, 3, and 4 for the interrupted rocksnail in this reach. Historical threats, including seasonal loss of flow and low dissolved oxygen, were eliminated in 1990 by implementation of minimum flows from Jordan Dam by the Alabama Power Company. As noted, ADCNR recognizes the Lower Coosa River as an appropriate location for imperiled mollusk reintroductions and has begun efforts to reestablish the interrupted rocksnail into this reach. Due to the extremely limited distribution of the interrupted rocksnail and the high degree of stochastic threats to the single natural population, reestablishing the species in the Lower Coosa River is essential to the conservation of the interrupted rocksnail.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Elmore and Shelby Counties, Alabama. The primary constituent elements (PCEs) of critical habitat for the rough hornsnail 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, bedrock, or mud substrates with low to moderate amounts of fine sediment and attached filamentous algae.

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 primary constituent elements, such as buildings, bridges, aqueducts, airports, and roads, and the land on which such structures are located.

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 interrupted rocksnail 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: We know little of the life history of pleurocerid snails; however, they are considered generalist scrappers and generally feed by ingesting periphyton (algae attached to hard surfaces) and biofilm detritus scraped off of the substrate by the snail’s radula (a horny band with minute teeth used to pull food into the mouth) (Morales and Ward 2000). Interrupted rocksnails have been observed grazing on silt-free gravel, cobble, and boulders (Johnson 2004) (USFWS, 2014).

Reproduction Narrative

Adult: In a hatchery setting, mean clutch size for 2 year old interrupted rocksnails was around 8.83 (3 – 18 eggs/clutch), and clutch size of females 3+ years was 13.63 (2-21 eggs/clutch) (Figure 4) (Johnson in litt. 2009) (USFWS, 2014).

Spatial Arrangements of the Population

Adult: Clumped (Inferred from USFWS, 2014 and NatureServe, 2015).

Environmental Specificity

Adult: Narrow/specialist (Inferred from USFWS, 2014 and NatureServe, 2015).

Tolerance Ranges/Thresholds

Adult: Low (Inferred from USFWS, 2014 and NatureServe, 2015).

Site Fidelity

Adult: High (Inferred from USFWS, 2014 and NatureServe, 2015).

Habitat Narrative

Adult: Interrupted rocksnails are currently found in shoal habitats with sand-boulder substrate, at water depths less than 50 centimeters (cm) (20 in), and in water currents less than 40 cm/second (sec) (16 in/sec) (Johnson 2004) (USFWS, 2014). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 2014; NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (Inferred from NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory (Inferred from NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: Low (Inferred from NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is vulnerable to random stochastic events that could easily eliminate the last remaining population. Limited dispersal capability and restricted range increase the vulnerability of the last remaining subpopulation of this species. A propagation and reintroduction program is underway (USFWS, 2010) (NatureServe, 2015). Mobility, Non-migratory, and immigration/emigration are inferred based on taxonomy and habitat.

Population Information and Trends

Population Trends:

Decreasing (Inferred from USFWS, 2014 and NatureServe, 2015)

Resiliency:

Low (Inferred from USFWS, 2014 and NatureServe, 2015)

Representation:

Low (Inferred from USFWS, 2014 and NatureServe, 2015)

Redundancy:

Low (Inferred from USFWS, 2014 and NatureServe, 2015)

Number of Populations:

1 to 5 (NatureServe, 2015)

Population Size:

Unknown (Inferred from USFWS, 2014 and NatureServe, 2015)

Population Narrative:

Numbers of rocksnails within the remaining subpopulation have been measured at average densities of 10 to 45 snails per square meter (Johnson and Evans, 2001); but have since declined to only 20 snails found during 6 search hours in 2004, possibly due to water contamination; followed by 89 snails found in 4 search hours at one shoal and 2 at another shoal in 2006; with a subsequent search in August 2006 under lower flow conditions resulting in the location of 89 snails in 4 search hours at one shoal and 2 snails in 4 search hours at another shoal (USFWS, 2010). Since their reintroduction into the Lower Coosa River of Alabama, a few of the 2003 cultured snails were observed in 2004 and another 18 located at a second release site in 2005 with 2 snails found at this latter site in 2006 (USFWS, 2010; NatureServe, 2015).Short-term Trend: Decline of >70% NatureServe, 2015). Previously listed as extinct, specimens from the single remaining population are being propagated by the Tennessee Aquarium and reintroduced (a few thousand at a time) into the Coosa River below Jordan Dam in Alabama (NatureServe, 2015). Resiliency, representation and redundancy are inferred based on habitat and taxonomy.

Threats and Stressors

Stressor: Range curtailment
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
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
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
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:

Protect and manage at least three geographically distinct populations for each species [To achieve this criterion, the populations can include the Oostanaula for the interrupted rocksnail and Yellowleaf Creek and Lower Coosa River for the rough hornsnail] (USFWS, 2014).

Achieve demonstrated and sustainable natural reproduction and recruitment in each population for each species as evident by multiple age classes of individuals, including naturally recruited juveniles, and recruitment rates exceeding mortality rates for a period of five years (USFWS, 2014).

Develop and implement habitat and population monitoring programs for each population (USFWS, 2014).

Delisting Criteria:
The present or threatened destruction, modification, or curtailment of its habitat or range (USFWS, 2014).

Disease or predation (USFWS, 2014)

The inadequacy of existing regulatory mechanisms (USFWS, 2014)

Other natural or manmade factors affecting its continued existence (USFWS, 2014)

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 (USFWS, 2014).

References

U.S. Fish and Wildlife Service. 2014. Recovery Plan for the Georgia pigtoe mussel, Interrupted rocksnail, and Rough hornsnail. Atlanta, Georgia. 55 pp

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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).

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SPECIES ACCOUNT: *Leptoxis plicata* (Plicate rocksnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/28/1998; Southeast Region (R4) (USFWS, 2016)

Physical Description

The plicate rocksnail is a pleurocerid snail that grows to about 20 mm (0.8 in) in length. Shells are subglobose with broadly rounded apertures. The body whorl may be ornamented with strong folds or plicae. Shell color is usually brown, occasionally green, and often with four equidistant color bands. The columella (central column or axis) is smooth, rounded, and typically pigmented in the upper half. The aperture is usually bluish-white, occasionally pink or white. The operculum (plate that closes the shell when the snail is retracted) is dark red, and moderately thick (Goodrich, 1922) (USFWS, 2005).

Taxonomy

The genus Leptoxis was formerly called Anculosa (Goodrich, 1922). The genus Leptoxis is a difficult taxonomic group. There is considerable disagreement in regard to the number of valid species (Goodrich, 1922; Burch, 1982). Dillon and Lydeard (1998) found high levels of genetic divergence among populations of Leptoxis praerosa and Leptoxis plicata and from all other populations of Leptoxis studied, indicating they are distinct species.In a preliminary analysis of molecular phylogeny of Mobile River basin pleurocerids, Lydeard et al. (1997) concluded that Leptoxis picta and Leptoxis plicata are quite distinct from one another and all other pleurocerids studied while Leptoxis taeniata and Leptoxis ampla sister taxa and Leptoxis picta the most basal of the group (NatureServe, 2015).

Historical Range

The plicate rocksnail historically occurred in the Black Warrior River, the Little Warrior River, and the Tombigbee River (Goodrich, 1922) (USFWS, 2005).

Current Range

Recent status surveys have located plicate rocksnail populations only in an approximately 88 km (55 mi) reach of the Locust Fork of the Black Warrior River, Jefferson and Blount counties, Alabama (Service Field Records, Jackson, Mississippi, 1991, 1992; Malcolm Pierson, Calera, Alabama, Field Notes, 1993). The latest survey information indicates that the snail has recently disappeared from the upstream two-thirds portion of that habitat and now appears to be restricted to an approximately 32 km (20 mi) reach in Jefferson County (Garner in litt., 1998, Johnson 2002) (USFWS, 2005).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Dispersal/Migration

Population Information and Trends

Population Trends:
Decreasing (inferred from USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Resiliency:
Low (inferred from USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Representation:
Low (inferred from USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Redundancy:
Low (inferred from USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Population Growth Rate:
Declining (inferred from USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Number of Populations:
1 - 5 (NatureServe, 2015)

Population Size:
2500 - 10,000 (NatureServe, 2015)

Adaptability:
Low (inferred from USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Population Narrative:
NatureServe (2015) notes that both long-term and short term population trends are decreasing and that at least two populations are currently decreasing in numbers. In addition NatureServe notes that there are 1 - 5 populations and that populations are estimated at between 2500 and 10,000 individuals. Resiliency, redundancy, representation and adaptability are inferred based on limited distribution and specific habitat needs as well as taxonomy (inferred from USFWS, 2005; USFWS, 2006; NatureServe, 2015).

Threats and Stressors

Stressor: Impoundments (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Dams change such areas by eliminating or reducing currents, and allowing sediments to accumulate on inundated channel habitats. Impounded waters also experience changes in water chemistry which could affect survival or reproduction of riverine snails. For example, many reservoirs in the Basin currently experience eutrophic (enrichment of a water body with nutrients) conditions and chronically low dissolved oxygen levels (Alabama Department of Environmental Management [ADEM], 1994, 1996). Such physical and chemical changes can affect feeding, respiration, and reproduction of these riffle and shoal snail species. In addition to

directly altering snail habitats, dams and their impounded waters also formed barriers to the movement of snails that continued to live below dams or in unimpounded tributaries. It is suspected that many such isolated colonies gradually disappear as a result of local water and habitat quality changes. Unable to emigrate (move out of the area), the isolated snail populations are vulnerable to local discharges as well as any detrimental land surface runoff within their watersheds. Although many watershed impacts have been temporary, eventually improving or even disappearing with the advent of new technology, management practices, or laws, dams and their impounded waters prevent natural recolonization by snail populations surviving elsewhere (USFWS, 2005).

Stressor: Water pollution (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Short-term and long-term impacts of point and nonpoint source water and habitat gradation continue to be a primary concern for the survival of all these snails, compounded by their isolation and localization. Point source discharges and land surface runoff (nonpoint pollution) can cause nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that are likely to seriously impact aquatic snails. Point sources of water quality degradation include municipal and industrial effluents. Nonpoint source pollution from land surface runoff can originate from virtually all land use activities, and may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and oils and greases (ADEM, 1996). During recent surveys for these snails, sediment deposition and/or dense algal mats (a sign of nutrient pollution of streams) were noted at many historic collection localities where snails had disappeared (Bogan and Pierson, 1993a, 1993b; Hartfield, 1991; Service Field Observations, 1992-1994, Jackson Field Office, MS) (USFWS, 2005).

Stressor: Sedimentation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Excessive sediments are believed to impact riverine snails requiring clean, hard shoal stream and river bottoms, by making the habitat unsuitable for feeding or reproduction. Similar impacts resulting from sediments have been noted for many other components of aquatic communities. For example, sediments have been shown to abrade and/or suffocate periphyton (organisms attached to underwater surfaces, upon which snails may feed); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters, 1995). Sediment is the most abundant pollutant produced in the Basin (ADEM, 1989). Potential sediment sources within a watershed include virtually all activities that disturb the land surface, and all localities currently occupied by these snails are affected to varying degrees by sedimentation. The amount and impact of sedimentation on snail habitats may be locally correlated with the land use practice, and the degree of implementation of agriculture, forestry, and construction Best Management Practices (USFWS, 2005).

Stressor: Runoff (USFWS, 2005)
Exposure:

Response:
Consequence:
Narrative: Land surface runoff contributes the majority of nutrients to streams in the Mobile River Basin (Atkins et al., 2004). Excessive nutrient input (from fertilizers, sewage waste, animal manure, etc.) can result in periodic low dissolved oxygen levels that are detrimental to aquatic species (Hynes, 1970). Nutrients also promote heavy algal growth that may cover and eliminate clean rock or gravel habitats of shoal dwelling snails. Nutrient and sediment pollution may have synergistic effects (a condition in which the toxic effect of two or more pollutants is much greater than the sum of the effects of the pollutants when operating individually) on freshwater snails and their habitats, as has been suggested for aquatic insects (Waters, 1995) (USFWS, 2005).

Stressor: Waste water treatment (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: The cylindrical lioplax, flat pebblesnail, and the round rocksnail currently survive in localized reaches of the Cahaba River drainage. Water quality studies in the upper Cahaba River drainage by the Geological Survey of Alabama (Shepard et al., 1996) found that discharges from 34 waste water treatment plants (WWTPs) in the upper drainage have contributed to water quality impairment. This was reflected by low levels of dissolved oxygen downstream of Birmingham; ammonia and chlorination by-products in excess of recommended water quality criteria; and eutrophication (demonstrated by dense algal mats and nightly sags in dissolved oxygen levels) due to excessive levels of phosphorus and nitrogen. The study noted that these problems are chronic and have been a factor in a loss of mollusk and fish diversity throughout the drainage. Their results indicate that the upper Cahaba River drainage is primarily impacted by nonpoint runoff and WWTPs through physical habitat destruction by sedimentation, and chronic stress from exposure to toxics and low dissolved oxygen. The middle Cahaba River is primarily impacted by eutrophication and associated effects (USFWS, 2005).

Stressor: Predation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Aquatic snails are consumed by various vertebrate predators, including fishes, mammals, and possibly birds. Predation by naturally occurring predators is a normal aspect of the population dynamics of a species and is not considered a threat to these species. However, the potential now exists for black carp (Mylopharyngodon piceus), a nonselective snail eating fish recently introduced into waters of the United States, to eventually enter the Mobile River Basin. Exotic black carp escaped to the Osage River in Missouri when hatchery ponds were flooded during a 1994 spring flood of the river (LMRCC newsletter, 1994). Although black carp have been banned for use in aquaculture in the State of Alabama, they are cultured and sold within the State of Mississippi (D. Reike, Mississippi Department of Wildlife, Fisheries, and Parks, pers. comm., 1997). The extent of stocking black carp for snail control in aquaculture ponds within the Basin is currently unknown (USFWS, 2005).

Recovery

Reclassification Criteria:

The plicate rocksnail will be considered for reclassification to threatened status when the following criteria are met:

1. The existing population has been shown to be stable or increasing over a period of 10 years (2 to 5 generations). This may be measured by numbers/area, catch per unit/effort, or other methods developed through population monitoring, and must be demonstrated through annual monitoring (USFWS, 2005).

2. There are no apparent or immediate threats to the listed population (see Listing/Recovery Criteria, below) (USFWS, 2005).

3. A captive population has been established at an appropriate facility, and the species has been successfully propagated (USFWS, 2005).

4. A minimum of two additional populations have been established (or discovered) within historic range (USFWS, 2005).

Delisting Criteria:
1. A minimum of 3 natural or re-established populations have been shown to be persistent (i.e., stable or increasing) for a period of 10 years (2 to 5 generations) (USFWS, 2005).

2. There are no apparent or immediate threats to the populations (see Listing/Recovery Factor Criteria, below). A population is defined as all snails occurring within a contiguous river or stream reach extending a minimum of 30 km (18 mi). Snails in a recovered population should be easily found in appropriate habitat throughout the occupied reach (USFWS, 2005).

Recovery Actions:
- The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin. The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin (USFWS, 2005).
- 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining

instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control. 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control (USFWS, 2005).

- 2. Consider options for free-flowing river and stream mitigation strategies that give high priority to avoidance and restoration. As noted above, avoidance of impact is the most important and immediate management need for maintaining existing imperiled populations and their habitats. However, long-term management requires the ability to accommodate changes in human use of the Basin's resources. Restoration of stream and river reaches, and rehabilitation of their aquatic communities will increase management options to accommodate future changes within the Basin. Compensating for aquatic habitat impacts can be an important component of aquatic habitat management. 2.l Identify appropriate mitigation measures for free flowing streams and rivers. When destruction or alteration of stream or river habitat is unavoidable, there should be an effort to restore or rehabilitate a comparable amount of instream aquatic habitat elsewhere in the Basin. Unfortunately, there is little guidance or consensus for the amount and degree of measures that could satisfy mitigation goals for free flowing riverine habitat. Federal, State, and local environmental and regulatory agencies and nongovernmental interests must work toward consensus on this problem, considering issues such as amount, quality, and location of river or stream segments under consideration for mitigation measures, and other alternatives, such as the need and possibility of establishing mitigation banks for permit applicants. 2.11 Investigate the potential of partnerships and assistance to relieve land use problems within watersheds as a form of mitigation. Concentrated land uses within watersheds can overwhelm the benefits of individual landowner Best Management Practices (BMPs). Animal wastes from concentrated husbandry of poultry, fish, and livestock is a major determinant of water quality in some watersheds. Urbanization of watersheds also causes complex runoff/water quality problems. Such problem areas may offer creative mitigation opportunities. Examples include developing equipment, facilities, or other components to establish centralized waste treatment for areas of high concentration of poultry farms and other animal feedlots; and providing assistance to communities for stormwater catchment and treatment (USFWS, 2005).
- 3. Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use. BMPs can be effective and practical actions identified to prevent or reduce nonpoint pollution from specific land use activities (ADEM, 1989). For example, agricultural BMPs are designed to reduce sediments, animal wastes, fertilizers, and pesticides in stormwater runoff (e.g., Alabama Soil and Water Conservation Committee (ASWCC), 1995). Mining BMPs address sediments and water quality parameters such as acidity and metal concentrations (e.g., ADEM, 1989). Silviculture BMPs include actions to minimize sediments, nutrients, organics, chemicals, and stream canopy removal (e.g., Alabama Forestry Commission, 1993). BMPs are also available for urban, construction, and homeowner activities that address stormwater runoff quality and quantity (ASWCC, 1992, MSDEQ, 1994). BMPs are developed by State and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and State resource agencies should continue to promote and improve BMPs when necessary as a nonregulatory approach to aquatic ecosystem management. 3.1 Work with State and private partners to promote land and water stewardship awareness. Local offices of State and Federal agencies and private organizations can become a primary source of encouragement and information for imperiled species and aquatic ecosystem management. For example, local offices (e.g, Soil and Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commissions, private industry groups, environmental groups, etc.) can identify watersheds

with listed species within their areas; inform local landowners of listed species' presence, needs, and special management concerns; recommend appropriate BMPs; and mediate landowner concerns or conflicts with appropriate State and/or Federal agencies. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity. Private industry groups can work with local landowners to customize BMPs where needed to address watershed problems and practices. 3.2 Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers in the Basin. Properly designed SMZs, which act as filter strips, can buffer the impacts of land use activities on water and stream bottom habitat quality. SMZs protect public and private property from erosion, reduce downstream sedimentation, and enhance fish and wildlife values for both game and nongame species. SMZs can also reduce nutrient levels in tributary streams in the Basin, which will help control eutrophication in Basin reservoirs (see Part I, Section C in Ecosystem Recovery Plan). Some farmlands adjacent to streams and rivers may qualify for SMZ set aside under the U.S. Department of Agriculture's Conservation Reserve Program and other initiatives. SMZs are widely recognized as cost effective habitat management practices. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. SMZs may be custom designed to protect stream habitat while achieving individual landowners management objectives. For example, the Natural Resources Conservation Service recommends SMZs from 22 to 91 meters (75 to 300 feet), with varying restrictions, depending on soil, slope, topography, and land use. Other government agencies and private groups make similar recommendations. SMZs are also effective in controlling urban and suburban stormwater runoff (USFWS, 2005).

- 4. Encourage and support community based watershed stewardship planning and action. Protection, restoration, and management planning for imperiled aquatic habitats is best accomplished by partners and stakeholders within a watershed. Such grassroots community planning educates participants about aquatic species, their habitat needs, and sensitivities; acknowledges local activities, problems and their effects on water; and leads to consensus based local solutions. Stewardship partnerships are essential in watersheds supporting listed or other imperiled aquatic species, and should be encouraged within any of the Basin's watersheds. Resource and regulatory agencies should offer support, materials, and technical and facilitation assistance when requested. 4.1 Reduce private land use/endangered species conflicts. Landowners and other watershed residents may feel threatened by the presence of listed aquatic species, and be reluctant to participate in watershed stewardship planning or action. In such cases, Watershed Habitat Conservation Plans, Safe Harbor Agreements, or other innovative avenues to assure and guarantee private land uses within watersheds should be developed (USFWS, 2005).
- 5. Develop and implement programs to educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship. Only an informed and proactive public can bring about ecosystem stabilization and rehabilitation. Successful ecosystem management will require public involvement, monitoring, and commitment of resources. Educational materials and programs should describe the concept and need for ecosystem management, its long-term economic and environmental advantages, and public and individual stewardship responsibilities (USFWS, 2005).
- 6. Conduct basic research on endemic aquatic species and apply the results toward management and protection of aquatic communities. The biology and ecology of endemic aquatic species in the Basin are poorly known. Information on distribution, habitat requirements, life stage sensitivity to contaminants, and the identification of mussel host

fish is essential to the recovery of endemic species and management and protection of their communities and habitats. All partners should be aware of research efforts and results, so that information can be immediately applied. 6.1 Survey and monitor the status of listed and other endemic aquatic species. Extant populations of listed and other endemic species should be located and their status monitored. 6.2 Conduct detailed physical and molecular genetic analyses of endemic species. Most of the Basin's endemic aquatic species have not been fully described anatomically. This information, in conjunction with genetic biochemical comparisons of populations and related species, may provide information important to population management and recovery. 6.3 Determine contaminant sensitivity for each life stage. It is known that juvenile and adult life stages of aquatic fauna may differ in sensitivity to contaminants. The technology and methodology should be developed to determine sub-lethal and lethal levels of pesticides, herbicides, and common contaminants and discharges to listed species and other endemic organisms in the Basin. 6.4 Conduct life history research on endemic species to include reproduction, food habits, age and growth, mortality factors. etc. Life history information may provide insight into past declines, current status of endemic species, weak links in the life cycle, and management guidance for their recovery. 6.41 Determine nutritional requirements of endemic species life stages. It is possible that juvenile forms of many taxa feed on different items than adults. Such requirements may be limiting factors in the survival of these species. Nutritional requirements must be known for successful captive propagation of endemic species (see Task 7) (USFWS, 2005).

- 7. Develop and implement technology for maintaining and propagating endemic species in captivity. Populations of endemic species in the Basin are isolated by large expanses of impounded, or otherwise severely altered, habitat. Maintenance of genetic flow between extant populations, and reintroduction of species to restored habitats, will require human intervention. Populations of many species are currently too low to justify translocation of wild stock between drainages. Captive propagation will be required to produce reintroduction stock if ecosystem restoration is eventually successful (see Task 8). Large numbers of juveniles and adults will also be needed for research to determine sensitivity of species to common contaminants (Task 6.3) (USFWS, 2005).
- 8. Reintroduce aquatic species into restored habitats, as appropriate. For many listed species, this step will be possible only when, and if, successful captive propagation technology is developed. Reintroduction will be closely coordinated with appropriate State agencies and affected private landowners. No reintroduction or translocation of species should be made without the concurrence of the appropriate State wildlife resource agencies and the knowledge and consensus of local watershed residents. 8.1 Identify sites for translocation/reintroduction. Potential sites for reintroduction consist of streams within the historic range of endemic species that meet the substrate, flow, water quality, and other environmental requirements of the species. Such sites need to be identified and monitored. 8.11 Survey and prioritize potential sites. Water quality, substrate composition, aquatic community composition, and watershed land uses should be characterized. Priority should be given to watersheds with appropriate habitat, diverse faunal assemblages, minimal land use impacts, and active management programs. 8.2 Translocate target endemic species to priority sites. Translocations should be conducted in a rigorous, scientific manner, and should be well-documented. 8.3 Monitor translocated populations. Stream and river reaches with translocated populations should be monitored and surveyed annually for a minimum of 10 years following translocation (USFWS, 2005)..

- 9. Monitor listed species population levels and distribution and periodically review ecosystem management strategy. Listed species will be monitored by Tasks 6.1 and 8.3. Changes in distribution (losses and gains) should be used to focus recovery efforts and priorities. Ecosystem management strategy should be periodically reviewed and revised, if appropriate, based on this information (USFWS, 2005).
- 10. Coordinate ecosystem management actions. The above recovery tasks approach ecosystem stabilization and management on three tiers: Federal and State regulatory authority and responsibility; private activities, public education and involvement; and research. Implementation of these tasks will involve multiple partners including State and Federal agencies, municipal and county governments, environmental and recreational organizations, civic groups, educational and research institutions, business and industry groups, landowners, and interested individuals. Successful implementation requires development of partnerships, coordination of on-going activities, determination and prioritization of needed actions, and monitoring recovery progress within each of the Basin's major drainages (USFWS, 2005).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS: • Conduct systematic population monitoring of extant and reintroduced populations of these snails and document potential threats to those populations. • Evaluate the status of the lacy elimia in Emauhee and Weewoka Creeks and confirm that its status in Cheaha Creek remains stable. Also conduct surveys within the Middle Coosa River tributaries that are within the historic range of the species. Results from these studies may suggest a need to upgrade its ESA status from threatened to endangered. • Continue to evaluate the extent and viability of the new populations of cylindrical lioplax within the Little Cahaba River, Yellowleaf Creek, and Choccolocco Creek, in order to determine if it meets the recovery criteria for downlisting to threatened. • Reassess and amend as needed the recovery plan for 6 Mobile River Basin aquatic snails, specifically, the recovery criteria and population criteria for recovery should be evaluated. • Continue to develop and implement habitat restoration plans for the streams where these species occur, or where they can be reintroduced. • Continue assisting the State’s propagation studies and efforts. • Work with State agencies, local groups, and individuals to protect and improve water quality in the drainages supporting the six snail species. • Implement all other recovery tasks (USFWS, 2016).

References

U.S. Fish and Wildlife Service. 2005. Recovery Plan for 6 Mobile River Basin Aquatic Snails. U.S. Fish and Wildlife Service, Jackson, Mississippi. pp

USFWS 2006. Cylindrical Lioplax (Lioplax cyclostomaformis), Flat Pebblesnail (Lepyrium showalteri), Plicate Rocksnail (Leptoxis plicata), Painted Rocksnail (Leptoxis taeniata), Round Rocksnail (Leptoxis ampla) and Lacy Elimia (Elimia crenatella) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Ecological Services Jackson, Mississippi

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SPECIES ACCOUNT: *Leptoxis taeniata* (Painted rocksnail)

Species Taxonomic and Listing Information

Listing Status: Threatened; October 28, 1998. R4

Physical Description

The painted rocksnail is a small to medium pleurocerid snail measuring about 19 mm (0.8 in) in length, and subglobose to oval in shape. The aperture is broadly ovate, and rounded anteriorly. Coloration varies from yellowish to olive-brown, and usually with four dark bands. Some shells may not have bands and some have the bands broken into squares or oblongs (see Goodrich, 1922 for a detailed description) (USFWS, 2005).

Historical Range

The painted rocksnail had the largest range of any rocksnail in the Mobile River Basin (Goodrich, 1922). It was historically known from the Coosa River and tributaries from the northeastern corner of St. Clair County, Alabama, downstream into the mainstem of the Alabama River to Claiborne, Monroe County, Alabama, and the Cahaba River below the Fall Line in Perry and Dallas counties, Alabama (Goodrich, 1922, Burch, 1989). Surveys by Service biologists and others (Bogan and Pierson, 1993a, 1993b; M. Pierson, in litt., 1993) in the Cahaba River, unimpounded portions of the Alabama River, and a number of free-f1owing Coosa River tributaries have located only three localized Coosa River drainage populations (USFWS, 2005).

Current Range

The painted rocksnail is currently known from the lower reaches of three Coosa River tributaries--Choccolocco Creek, Talladega County; Buxahatchee Creek, Shelby County (Bogan and Pierson, 1993a); and Ohatchee Creek, Calhoun County, Alabama (Pierson in litt., 1993) (USFWS, 2005).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Unknown

Reproduction Narrative

Adult: Adult rocksnails move very little, and females probably glue their eggs to stones in the same habitat (Goodrich, 1922). Longevity in the painted rocksnail is unknown; however, Heller (1990) reported a short life span (less than 2 years) in a Tennessee River rocksnail (USFWS, 2005).

Environmental Specificity

Adult: Narrow/Specialist (inferred from USFWS, 2005)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2005 and NatureServe, 2015)

Site Fidelity

Adult: High (inferred from USFWS, 2005)

Habitat Narrative

Adult: Painted rocksnails are gill breathing snails found attached to cobble, gravel, or other hard substrates in the strong currents of riffles (a shallow area in a streambed that causes ripples in the water) and shoals (USFWS, 2005; NatureServe, 2015). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs (USFWS, 2005; NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2005)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS, 2005 and USFWS, 2006)

Dispersal

Adult: Low (inferred from USFWS, 2005)

Immigration/Emigration

Adult: Unlikely (inferred from USFWS, 2005)

Dispersal/Migration Narrative

Adult: Low mobility/motility and dispersal are inferred based on taxa and habitat information as are non-migratory and low dispersal status (USFWS, 2005; USFWS, 2006; NatureServe, 2015)

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (inferred from NatureServe, 2015)

Representation:

Low (inferred from NatureServe, 2015)

Redundancy:

Low (inferred from NatureServe, 2015)

Number of Populations:

1 to 5 (NatureServe, 2015)

Population Size:

Unknown (inferred from NatureServe, 2015)

Population Narrative:

Decreasing population trends and number of populations is noted in NatureServe (2015). Resiliency, Representation and Redundancy are inferred based on population size and habitat requirements (USFWS, 2005; NatureServe, 2015).

Threats and Stressors

Stressor: Impoundments (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Dams change such areas by eliminating or reducing currents, and allowing sediments to accumulate on inundated channel habitats. Impounded waters also experience changes in water chemistry which could affect survival or reproduction of riverine snails. For example, many reservoirs in the Basin currently experience eutrophic (enrichment of a water body with nutrients) conditions and chronically low dissolved oxygen levels (Alabama Department of Environmental Management [ADEM], 1994, 1996). Such physical and chemical changes can affect feeding, respiration, and reproduction of these riffle and shoal snail species. In addition to directly altering snail habitats, dams and their impounded waters also formed barriers to the movement of snails that continued to live below dams or in unimpounded tributaries. It is suspected that many such isolated colonies gradually disappear as a result of local water and habitat quality changes. Unable to emigrate (move out of the area), the isolated snail populations are vulnerable to local discharges as well as any detrimental land surface runoff within their watersheds. Although many watershed impacts have been temporary, eventually improving or even disappearing with the advent of new technology, management practices, or laws, dams and their impounded waters prevent natural recolonization by snail populations surviving elsewhere (USFWS, 2005).

Stressor: Water pollution (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Short-term and long-term impacts of point and nonpoint source water and habitat gradation continue to be a primary concern for the survival of all these snails, compounded by their isolation and localization. Point source discharges and land surface runoff (nonpoint pollution) can cause nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that are likely to seriously impact aquatic snails. Point sources of water quality degradation include municipal and industrial effluents. Nonpoint source pollution from land surface runoff can originate from virtually all land use activities, and may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and oils and greases (ADEM, 1996). During recent surveys for these snails, sediment deposition and/or dense algal mats (a sign of nutrient pollution of streams) were noted at many historic collection localities where snails had disappeared (Bogan and Pierson, 1993a, 1993b; Hartfield, 1991; Service Field Observations, 1992-1994, Jackson Field Office, MS) (USFWS, 2005).

Stressor: Sedimentation (USFWS, 2005)

Exposure:
Response:
Consequence:
Narrative: Excessive sediments are believed to impact riverine snails requiring clean, hard shoal stream and river bottoms, by making the habitat unsuitable for feeding or reproduction. Similar impacts resulting from sediments have been noted for many other components of aquatic communities. For example, sediments have been shown to abrade and/or suffocate periphyton (organisms attached to underwater surfaces, upon which snails may feed); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters, 1995). Sediment is the most abundant pollutant produced in the Basin (ADEM, 1989). Potential sediment sources within a watershed include virtually all activities that disturb the land surface, and all localities currently occupied by these snails are affected to varying degrees by sedimentation. The amount and impact of sedimentation on snail habitats may be locally correlated with the land use practice, and the degree of implementation of agriculture, forestry, and construction Best Management Practices (USFWS, 2005).

Stressor: Runoff (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Land surface runoff contributes the majority of nutrients to streams in the Mobile River Basin (Atkins et al., 2004). Excessive nutrient input (from fertilizers, sewage waste, animal manure, etc.) can result in periodic low dissolved oxygen levels that are detrimental to aquatic species (Hynes, 1970). Nutrients also promote heavy algal growth that may cover and eliminate clean rock or gravel habitats of shoal dwelling snails. Nutrient and sediment pollution may have synergistic effects (a condition in which the toxic effect of two or more pollutants is much greater than the sum of the effects of the pollutants when operating individually) on freshwater snails and their habitats, as has been suggested for aquatic insects (Waters, 1995) (USFWS, 2005).

Stressor: Waste water treatment (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: The cylindrical lioplax, flat pebblesnail, and the round rocksnail currently survive in localized reaches of the Cahaba River drainage. Water quality studies in the upper Cahaba River drainage by the Geological Survey of Alabama (Shepard et al., 1996) found that discharges from 34 waste water treatment plants (WWTPs) in the upper drainage have contributed to water quality impairment. This was reflected by low levels of dissolved oxygen downstream of Birmingham; ammonia and chlorination by-products in excess of recommended water quality criteria; and eutrophication (demonstrated by dense algal mats and nightly sags in dissolved oxygen levels) due to excessive levels of phosphorus and nitrogen. The study noted that these problems are chronic and have been a factor in a loss of mollusk and fish diversity throughout the drainage. Their results indicate that the upper Cahaba River drainage is primarily impacted by nonpoint runoff and WWTPs through physical habitat destruction by sedimentation, and chronic stress from exposure to toxics and low dissolved oxygen. The middle Cahaba River is primarily impacted by eutrophication and associated effects (USFWS, 2005).

Stressor: Predation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Aquatic snails are consumed by various vertebrate predators, including fishes, mammals, and possibly birds. Predation by naturally occurring predators is a normal aspect of the population dynamics of a species and is not considered a threat to these species. However, the potential now exists for black carp (Mylopharyngodon piceus), a nonselective snail eating fish recently introduced into waters of the United States, to eventually enter the Mobile River Basin. Exotic black carp escaped to the Osage River in Missouri when hatchery ponds were flooded during a 1994 spring flood of the river (LMRCC newsletter, 1994). Although black carp have been banned for use in aquaculture in the State of Alabama, they are cultured and sold within the State of Mississippi (D. Reike, Mississippi Department of Wildlife, Fisheries, and Parks, pers. comm., 1997). The extent of stocking black carp for snail control in aquaculture ponds within the Basin is currently unknown (USFWS, 2005).

Recovery

Delisting Criteria:
1. A minimum of 3 natural or re-established populations have been shown to be persistent (i.e., stable or increasing) for a period of 10 years (2 to 5 generations) (USFWS, 2005).

2. There are no apparent or immediate threats to the populations (see Listing/Recovery Factor Criteria, below). A population is defined as all snails occurring within a contiguous river or stream reach extending a minimum of 30 km (18 mi). Snails in a recovered population should be easily found in appropriate habitat throughout the occupied reach (USFWS, 2005).

Recovery Actions:
- The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin. The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin (USFWS, 2005).
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listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control. 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control (USFWS, 2005).

- 2. Consider options for free-flowing river and stream mitigation strategies that give high priority to avoidance and restoration. As noted above, avoidance of impact is the most important and immediate management need for maintaining existing imperiled populations and their habitats. However, long-term management requires the ability to accommodate changes in human use of the Basin's resources. Restoration of stream and river reaches, and rehabilitation of their aquatic communities will increase management options to accommodate future changes within the Basin. Compensating for aquatic habitat impacts can be an important component of aquatic habitat management. 2.1 Identify appropriate mitigation measures for free flowing streams and rivers. When destruction or alteration of stream or river habitat is unavoidable, there should be an effort to restore or rehabilitate a comparable amount of instream aquatic habitat elsewhere in the Basin. Unfortunately, there is little guidance or consensus for the amount and degree of measures that could satisfy mitigation goals for free flowing riverine habitat. Federal, State, and local environmental and regulatory agencies and nongovernmental interests must work toward consensus on this problem, considering issues such as amount, quality, and location of river or stream segments under consideration for mitigation measures, and other alternatives, such as the need and possibility of establishing mitigation banks for permit applicants. 2.11 Investigate the potential of partnerships and assistance to relieve land use problems within watersheds as a form of mitigation. Concentrated land uses within watersheds can overwhelm the benefits of individual landowner Best Management Practices (BMPs). Animal wastes from concentrated husbandry of poultry, fish, and livestock is a major determinant of water quality in some watersheds. Urbanization of watersheds also causes complex runoff/water quality problems. Such problem areas may offer creative mitigation opportunities. Examples include developing equipment, facilities, or other components to establish centralized waste treatment for areas of high concentration of poultry farms and other animal feedlots; and providing assistance to communities for stormwater catchment and treatment (USFWS, 2005).
- 3. Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use. BMPs can be effective and practical actions identified to prevent or reduce nonpoint pollution from specific land use activities (ADEM, 1989). For example, agricultural BMPs are designed to reduce sediments, animal wastes, fertilizers, and pesticides in stormwater runoff (e.g., Alabama Soil and Water Conservation Committee (ASWCC), 1995). Mining BMPs address sediments and water quality parameters such as acidity and metal concentrations (e.g., ADEM, 1989). Silviculture BMPs include actions to minimize sediments, nutrients, organics, chemicals, and stream canopy removal (e.g., Alabama Forestry Commission, 1993). BMPs are also available for urban, construction, and homeowner activities that address stormwater runoff quality and quantity (ASWCC, 1992, MSDEQ, 1994). BMPs are developed by State and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and State resource agencies should continue to promote and improve BMPs when necessary as a nonregulatory approach to aquatic ecosystem management. 3.1 Work with State and private partners to promote land and water stewardship awareness. Local offices of State and Federal agencies and private organizations can become a primary source of encouragement and information for imperiled species and aquatic ecosystem management. For example, local offices (e.g, Soil

and Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commissions, private industry groups, environmental groups, etc.) can identify watersheds with listed species within their areas; inform local landowners of listed species' presence, needs, and special management concerns; recommend appropriate BMPs; and mediate landowner concerns or conflicts with appropriate State and/or Federal agencies. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity. Private industry groups can work with local landowners to customize BMPs where needed to address watershed problems and practices.   3.2 Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers in the Basin. Properly designed SMZs, which act as filter strips, can buffer the impacts of land use activities on water and stream bottom habitat quality. SMZs protect public and private property from erosion, reduce downstream sedimentation, and enhance fish and wildlife values for both game and nongame species. SMZs can also reduce nutrient levels in tributary streams in the Basin, which will help control eutrophication in Basin reservoirs (see Part I, Section C in Ecosystem Recovery Plan). Some farmlands adjacent to streams and rivers may qualify for SMZ set aside under the U.S. Department of Agriculture's Conservation Reserve Program and other initiatives. SMZs are widely recognized as cost effective habitat management practices. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. SMZs may be custom designed to protect stream habitat while achieving individual landowners management objectives. For example, the Natural Resources Conservation Service recommends SMZs from 22 to 91 meters (75 to 300 feet), with varying restrictions, depending on soil, slope, topography, and land use. Other government agencies and private groups make similar recommendations. SMZs are also effective in controlling urban and suburban stormwater runoff (USFWS, 2005).

- 4. Encourage and support community based watershed stewardship planning and action. Protection, restoration, and management planning for imperiled aquatic habitats is best accomplished by partners and stakeholders within a watershed. Such grassroots community planning educates participants about aquatic species, their habitat needs, and sensitivities; acknowledges local activities, problems and their effects on water; and leads to consensus based local solutions. Stewardship partnerships are essential in watersheds supporting listed or other imperiled aquatic species, and should be encouraged within any of the Basin's watersheds. Resource and regulatory agencies should offer support, materials, and technical and facilitation assistance when requested.   4.1 Reduce private land use/endangered species conflicts. Landowners and other watershed residents may feel threatened by the presence of listed aquatic species, and be reluctant to participate in watershed stewardship planning or action. In such cases, Watershed Habitat Conservation Plans, Safe Harbor Agreements, or other innovative avenues to assure and guarantee private land uses within watersheds should be developed (USFWS, 2005).
- 5. Develop and implement programs to educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship. Only an informed and proactive public can bring about ecosystem stabilization and rehabilitation. Successful ecosystem management will require public involvement, monitoring, and commitment of resources. Educational materials and programs should describe the concept and need for ecosystem management, its long-term economic and environmental advantages, and public and individual stewardship responsibilities (USFWS, 2005).
- 6. Conduct basic research on endemic aquatic species and apply the results toward management and protection of aquatic communities. The biology and ecology of endemic

aquatic species in the Basin are poorly known. Information on distribution, habitat requirements, life stage sensitivity to contaminants, and the identification of mussel host fish is essential to the recovery of endemic species and management and protection of their communities and habitats. All partners should be aware of research efforts and results, so that information can be immediately applied. 6.1 Survey and monitor the status of listed and other endemic aquatic species. Extant populations of listed and other endemic species should be located and their status monitored. 6.2 Conduct detailed physical and molecular genetic analyses of endemic species. Most of the Basin's endemic aquatic species have not been fully described anatomically. This information, in conjunction with genetic biochemical comparisons of populations and related species, may provide information important to population management and recovery. 6.3 Determine contaminant sensitivity for each life stage. It is known that juvenile and adult life stages of aquatic fauna may differ in sensitivity to contaminants. The technology and methodology should be developed to determine sub-lethal and lethal levels of pesticides, herbicides, and common contaminants and discharges to listed species and other endemic organisms in the Basin. 6.4 Conduct life history research on endemic species to include reproduction, food habits, age and growth, mortality factors. etc. Life history information may provide insight into past declines, current status of endemic species, weak links in the life cycle, and management guidance for their recovery. 6.41 Determine nutritional requirements of endemic species life stages. It is possible that juvenile forms of many taxa feed on different items than adults. Such requirements may be limiting factors in the survival of these species. Nutritional requirements must be known for successful captive propagation of endemic species (see Task 7) (USFWS, 2005).

- 7. Develop and implement technology for maintaining and propagating endemic species in captivity. Populations of endemic species in the Basin are isolated by large expanses of impounded, or otherwise severely altered, habitat. Maintenance of genetic flow between extant populations, and reintroduction of species to restored habitats, will require human intervention. Populations of many species are currently too low to justify translocation of wild stock between drainages. Captive propagation will be required to produce reintroduction stock if ecosystem restoration is eventually successful (see Task 8). Large numbers of juveniles and adults will also be needed for research to determine sensitivity of species to common contaminants (Task 6.3) (USFWS, 2005).
- 8. Reintroduce aquatic species into restored habitats, as appropriate. For many listed species, this step will be possible only when, and if, successful captive propagation technology is developed. Reintroduction will be closely coordinated with appropriate State agencies and affected private landowners. No reintroduction or translocation of species should be made without the concurrence of the appropriate State wildlife resource agencies and the knowledge and consensus of local watershed residents. 8.1 Identify sites for translocation/reintroduction. Potential sites for reintroduction consist of streams within the historic range of endemic species that meet the substrate, flow, water quality, and other environmental requirements of the species. Such sites need to be identified and monitored. 8.11 Survey and prioritize potential sites. Water quality, substrate composition, aquatic community composition, and watershed land uses should be characterized. Priority should be given to watersheds with appropriate habitat, diverse faunal assemblages, minimal land use impacts, and active management programs. 8.2 Translocate target endemic species to priority sites. Translocations should be conducted in a rigorous, scientific manner, and should be well-documented. 8.3 Monitor translocated populations. Stream and river

reaches with translocated populations should be monitored and surveyed annually for a minimum of 10 years following translocation (USFWS, 2005)..

- 9. Monitor listed species population levels and distribution and periodically review ecosystem management strategy. Listed species will be monitored by Tasks 6.1 and 8.3. Changes in distribution (losses and gains) should be used to focus recovery efforts and priorities. Ecosystem management strategy should be periodically reviewed and revised, if appropriate, based on this information (USFWS, 2005).
- 10. Coordinate ecosystem management actions. The above recovery tasks approach ecosystem stabilization and management on three tiers: Federal and State regulatory authority and responsibility; private activities, public education and involvement; and research. Implementation of these tasks will involve multiple partners including State and Federal agencies, municipal and county governments, environmental and recreational organizations, civic groups, educational and research institutions, business and industry groups, landowners, and interested individuals. Successful implementation requires development of partnerships, coordination of on-going activities, determination and prioritization of needed actions, and monitoring recovery progress within each of the Basin's major drainages (USFWS, 2005).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS: • Conduct systematic population monitoring of extant and reintroduced populations of these snails and document potential threats to those populations. • Evaluate the status of the lacy elimia in Emauhee and Weewoka Creeks and confirm that its status in Cheaha Creek remains stable. Also conduct surveys within the Middle Coosa River tributaries that are within the historic range of the species. Results from these studies may suggest a need to upgrade its ESA status from threatened to endangered. • Continue to evaluate the extent and viability of the new populations of cylindrical lioplax within the Little Cahaba River, Yellowleaf Creek, and Choccolocco Creek, in order to determine if it meets the recovery criteria for downlisting to threatened. • Reassess and amend as needed the recovery plan for 6 Mobile River Basin aquatic snails, specifically, the recovery criteria and population criteria for recovery should be evaluated. • Continue to develop and implement habitat restoration plans for the streams where these species occur, or where they can be reintroduced. • Continue assisting the State’s propagation studies and efforts. • Work with State agencies, local groups, and individuals to protect and improve water quality in the drainages supporting the six snail species. • Implement all other recovery tasks (USFWS, 2016).

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SPECIES ACCOUNT: *Lepyrium showalteri* (Flat pebblesnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; October 28, 1998. Southeast region (R4)

Physical Description

The shells are ovate in outline, flattened, and grow to 3.5 to 4.4 mm (0.1 to 0.2 in) high and 4 to 5 mm (0.2 in) wide. The umbilical area is imperforate (no opening), and there are 2 to 3 whorls which rapidly expand. The anatomy of this species has been described in detail by Thompson (1984) (USFWS, 2005; NatureServe, 2015).

Taxonomy

The flat pebblesnail is a small snail in the family Hydrobiidae; however, the species has a large and distinct shell, relative to other hydrobiid species. This snail's shell is also distinguished by its depressed spire and expanded, flattened body whorl (USFWS, 2005).

Historical Range

The flat pebblesnail was historically known from the mainstem Coosa River in Shelby and Talladega counties; the Cahaba River in Bibb and Dallas counties; and Little Cahaba River in Bibb County, Alabama (Thompson, 1984). The flat pebblesnail has not been found in the Coosa River portion of its range since the construction of Lay and Logan Martin Dams, and recent survey efforts have failed to locate any surviving populations outside of the Cahaba River drainage (Bogan and Pierson, 1993a, 1993b; McGregor et al. 1996; Service Field Records, Jackson, Mississippi, 1989-1996; Bogan in litt., 1995; M. Pierson Field Records, Calera, Alabama, in litt., 1993-1994; J. Garner, pers. comm., 1996; J. Johnson, in litt., 1996) (USFWS, 2005).

Current Range

The flat pebblesnail is currently known from one site on the Little Cahaba River, Bibb County, and from a single shoal series on the Cahaba River above the Fall Line, Shelby County, Alabama (Bogan and Pierson, 1993b) (USFWS, 2005).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Unknown

Reproduction Narrative

Adult: Eggs are laid in capsules on hard surfaces (Thompson, 1984). Life span appears to be 1 year (P. Johnson, pers. comm., 2005). Little else is known of the natural history of this species (USFWS, 2005).

Spatial Arrangements of the Population

Adult: Clumped (Inferred from USFWS, 2005)

Environmental Specificity

Adult: Narrow/Specialist (Inferred from USFWS, 2005)

Tolerance Ranges/Thresholds

Adult: Low (Inferred from USFWS, 2005)

Site Fidelity

Adult: High (Inferred from USFWS, 2005)

Habitat Narrative

Adult: The flat pebblesnail is found attached to clean, smooth stones in rapid currents of river shoals (USFWS, 2005). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 2005; NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (Inferred from USFWS, 2005)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (Inferred from USFWS, 2005)

Dispersal

Adult: Low (Inferred from USFWS, 2005)

Immigration/Emigration

Adult: Unlikely (Inferred from USFWS, 2005)

Dispersal/Migration Narrative

Adult: Mobility, migration, dispersal and immagration/emigration are inferred based on taxa and habitat (USFWS, 2005; NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (inferred from NatureServe, 2015)

Representation:

Low (inferred from NatureServe, 2015)

Redundancy:

Low (inferred from NatureServe, 2015)

Population Growth Rate:

Declining (inferred from NatureServe, 2015 and USFWS, 2005)

Number of Populations:
1 to 5 (NatureServe, 2015)

Population Size:
Unknown

Population Narrative:
Decreasing population trends and number of populations is noted in NatureServe (2015). Resiliency, Representation and Redundancy are inferred based on population size and habitat requirements (USFWS, 2005; Natureserve, 2015).

Threats and Stressors

Stressor: Impoundments (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Dams change such areas by eliminating or reducing currents, and allowing sediments to accumulate on inundated channel habitats. Impounded waters also experience changes in water chemistry which could affect survival or reproduction of riverine snails. For example, many reservoirs in the Basin currently experience eutrophic (enrichment of a water body with nutrients) conditions and chronically low dissolved oxygen levels (Alabama Department of Environmental Management [ADEM], 1994, 1996). Such physical and chemical changes can affect feeding, respiration, and reproduction of these riffle and shoal snail species. In addition to directly altering snail habitats, dams and their impounded waters also formed barriers to the movement of snails that continued to live below dams or in unimpounded tributaries. It is suspected that many such isolated colonies gradually disappear as a result of local water and habitat quality changes. Unable to emigrate (move out of the area), the isolated snail populations are vulnerable to local discharges as well as any detrimental land surface runoff within their watersheds. Although many watershed impacts have been temporary, eventually improving or even disappearing with the advent of new technology, management practices, or laws, dams and their impounded waters prevent natural recolonization by snail populations surviving elsewhere (USFWS, 2005).

Stressor: Water pollution (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Short-term and long-term impacts of point and nonpoint source water and habitat gradation continue to be a primary concern for the survival of all these snails, compounded by their isolation and localization. Point source discharges and land surface runoff (nonpoint pollution) can cause nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that are likely to seriously impact aquatic snails. Point sources of water quality degradation include municipal and industrial effluents. Nonpoint source pollution from land surface runoff can originate from virtually all land use activities, and may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic

tank and gray water leakage, and oils and greases (ADEM, 1996). During recent surveys for these snails, sediment deposition and/or dense algal mats (a sign of nutrient pollution of streams) were noted at many historic collection localities where snails had disappeared (Bogan and Pierson, 1993a, 1993b; Hartfield, 1991; Service Field Observations, 1992-1994, Jackson Field Office, MS) (USFWS, 2005).

Stressor: Sedimentation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Excessive sediments are believed to impact riverine snails requiring clean, hard shoal stream and river bottoms, by making the habitat unsuitable for feeding or reproduction. Similar impacts resulting from sediments have been noted for many other components of aquatic communities. For example, sediments have been shown to abrade and/or suffocate periphyton (organisms attached to underwater surfaces, upon which snails may feed); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters, 1995). Sediment is the most abundant pollutant produced in the Basin (ADEM, 1989). Potential sediment sources within a watershed include virtually all activities that disturb the land surface, and all localities currently occupied by these snails are affected to varying degrees by sedimentation. The amount and impact of sedimentation on snail habitats may be locally correlated with the land use practice, and the degree of implementation of agriculture, forestry, and construction Best Management Practices (USFWS, 2005).

Stressor: Runoff (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Land surface runoff contributes the majority of nutrients to streams in the Mobile River Basin (Atkins et al., 2004). Excessive nutrient input (from fertilizers, sewage waste, animal manure, etc.) can result in periodic low dissolved oxygen levels that are detrimental to aquatic species (Hynes, 1970). Nutrients also promote heavy algal growth that may cover and eliminate clean rock or gravel habitats of shoal dwelling snails. Nutrient and sediment pollution may have synergistic effects (a condition in which the toxic effect of two or more pollutants is much greater than the sum of the effects of the pollutants when operating individually) on freshwater snails and their habitats, as has been suggested for aquatic insects (Waters, 1995) (USFWS, 2005).

Stressor: Waste water treatment (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: The cylindrical lioplax, flat pebblesnail, and the round rocksnail currently survive in localized reaches of the Cahaba River drainage. Water quality studies in the upper Cahaba River drainage by the Geological Survey of Alabama (Shepard et al., 1996) found that discharges from 34 waste water treatment plants (WWTPs) in the upper drainage have contributed to water quality impairment. This was reflected by low levels of dissolved oxygen downstream of Birmingham; ammonia and chlorination by-products in excess of recommended water quality criteria; and eutrophication (demonstrated by dense algal mats and nightly sags in dissolved

oxygen levels) due to excessive levels of phosphorus and nitrogen. The study noted that these problems are chronic and have been a factor in a loss of mollusk and fish diversity throughout the drainage. Their results indicate that the upper Cahaba River drainage is primarily impacted by nonpoint runoff and WWTPs through physical habitat destruction by sedimentation, and chronic stress from exposure to toxics and low dissolved oxygen. The middle Cahaba River is primarily impacted by eutrophication and associated effects (USFWS, 2005).

Stressor: Predation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Aquatic snails are consumed by various vertebrate predators, including fishes, mammals, and possibly birds. Predation by naturally occurring predators is a normal aspect of the population dynamics of a species and is not considered a threat to these species. However, the potential now exists for black carp (Mylopharyngodon piceus), a nonselective snail eating fish recently introduced into waters of the United States, to eventually enter the Mobile River Basin. Exotic black carp escaped to the Osage River in Missouri when hatchery ponds were flooded during a 1994 spring flood of the river (LMRCC newsletter, 1994). Although black carp have been banned for use in aquaculture in the State of Alabama, they are cultured and sold within the State of Mississippi (D. Reike, Mississippi Department of Wildlife, Fisheries, and Parks, pers. comm., 1997). The extent of stocking black carp for snail control in aquaculture ponds within the Basin is currently unknown (USFWS, 2005).

Recovery

Reclassification Criteria:
The flat pebblesnail will be considered for reclassification to threatened status when the following criteria are met: (USFWS, 2005).

1. The existing population has been shown to be stable or increasing over a period of 10 years (2 to 5 generations). This may be measured by numbers/area, catch per unit/effort, or other methods developed through population monitoring, and must be demonstrated through annual monitoring (USFWS, 2005).

2. There are no apparent or immediate threats to the listed population (see Listing/Recovery Criteria, below) (USFWS, 2005).

3. A captive population has been established at an appropriate facility, and the species has been successfully propagated (USFWS, 2005).

4. A minimum of two additional populations have been established (or discovered) within historic range (USFWS, 2005).

Delisting Criteria:
1. A minimum of 3 natural or re-established populations have been shown to be persistent (i.e., stable or increasing) for a period of 10 years (2 to 5 generations) (USFWS, 2005).

2. There are no apparent or immediate threats to the populations (see Listing/Recovery Factor Criteria, below). A population is defined as all snails occurring within a contiguous river or stream reach extending a minimum of 30 km (18 mi). Snails in a recovered population should be easily found in appropriate habitat throughout the occupied reach (USFWS, 2005).

Recovery Actions:

- The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin. The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin (USFWS, 2005).
- 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control. 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally

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- 2. Consider options for free-flowing river and stream mitigation strategies that give high priority to avoidance and restoration. As noted above, avoidance of impact is the most important and immediate management need for maintaining existing imperiled populations and their habitats. However, long-term management requires the ability to accommodate changes in human use of the Basin's resources. Restoration of stream and river reaches, and rehabilitation of their aquatic communities will increase management options to accommodate future changes within the Basin. Compensating for aquatic habitat impacts can be an important component of aquatic habitat management. 2.1 Identify appropriate mitigation measures for free flowing streams and rivers. When destruction or alteration of stream or river habitat is unavoidable, there should be an effort to restore or rehabilitate a comparable amount of instream aquatic habitat elsewhere in the Basin. Unfortunately, there is little guidance or consensus for the amount and degree of measures that could satisfy mitigation goals for free flowing riverine habitat. Federal, State, and local environmental and regulatory agencies and nongovernmental interests must work toward consensus on this problem, considering issues such as amount, quality, and location of river or stream segments under consideration for mitigation measures, and other alternatives, such as the need and possibility of establishing mitigation banks for permit applicants. 2.11 Investigate the potential of partnerships and assistance to relieve land use problems within watersheds as a form of mitigation. Concentrated land uses within watersheds can overwhelm the benefits of individual landowner Best Management Practices (BMPs). Animal wastes from concentrated husbandry of poultry, fish, and livestock is a major determinant of water quality in some watersheds. Urbanization of watersheds also causes complex runoff/water quality problems. Such problem areas may offer creative mitigation opportunities. Examples include developing equipment, facilities, or other components to establish centralized waste treatment for areas of high concentration of poultry farms and other animal feedlots; and providing assistance to communities for stormwater catchment and treatment (USFWS, 2005).

- 3. Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use. BMPs can be effective and practical actions identified to prevent or reduce nonpoint pollution from specific land use activities (ADEM, 1989). For example, agricultural BMPs are designed to reduce sediments, animal wastes, fertilizers, and pesticides in stormwater runoff (e.g., Alabama Soil and Water Conservation Committee (ASWCC), 1995). Mining BMPs address sediments and water quality parameters such as acidity and metal concentrations (e.g., ADEM, 1989). Silviculture BMPs include actions to minimize sediments, nutrients, organics, chemicals, and stream canopy removal (e.g., Alabama Forestry Commission, 1993). BMPs are also available for urban, construction, and homeowner activities that address stormwater runoff quality and quantity (ASWCC, 1992, MSDEQ, 1994). BMPs are developed by State and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and State resource agencies should continue to promote and improve BMPs when necessary as a nonregulatory approach to aquatic ecosystem management. 3.1 Work with State and private partners to promote land and water stewardship awareness. Local offices of State and Federal agencies and private organizations can become a primary source of encouragement and information for imperiled species and aquatic ecosystem management. For example, local offices (e.g, Soil and Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commissions, private industry groups, environmental groups, etc.) can identify watersheds with listed species within their areas; inform local landowners of listed species' presence, needs, and special management concerns; recommend appropriate BMPs; and mediate landowner concerns or conflicts with appropriate State and/or Federal agencies. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity. Private industry groups can work with local landowners to customize BMPs where needed to address watershed problems and practices. 3.2 Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers in the Basin. Properly designed SMZs, which act as filter strips, can buffer the impacts of land use activities on water and stream bottom habitat quality. SMZs protect public and private property from erosion, reduce downstream sedimentation, and enhance fish and wildlife values for both game and nongame species. SMZs can also reduce nutrient levels in tributary streams in the Basin, which will help control eutrophication in Basin reservoirs (see Part I, Section C in Ecosystem Recovery Plan). Some farmlands adjacent to streams and rivers may qualify for SMZ set aside under the U.S. Department of Agriculture's Conservation Reserve Program and other initiatives. SMZs are widely recognized as cost effective habitat management practices. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. SMZs may be custom designed to protect stream habitat while achieving individual landowners management objectives. For example, the Natural Resources Conservation Service recommends SMZs from 22 to 91 meters (75 to 300 feet), with varying restrictions, depending on soil, slope, topography, and land use.

Other government agencies and private groups make similar recommendations. SMZs are also effective in controlling urban and suburban stormwater runoff (USFWS, 2005).

- 4. Encourage and support community based watershed stewardship planning and action. Protection, restoration, and management planning for imperiled aquatic habitats is best accomplished by partners and stakeholders within a watershed. Such grassroots community planning educates participants about aquatic species, their habitat needs, and sensitivities; acknowledges local activities, problems and their effects on water; and leads to consensus based local solutions. Stewardship partnerships are essential in watersheds supporting listed or other imperiled aquatic species, and should be encouraged within any of the Basin's watersheds. Resource and regulatory agencies should offer support, materials, and technical and facilitation assistance when requested. 4.1 Reduce private land use/endangered species conflicts. Landowners and other watershed residents may feel threatened by the presence of listed aquatic species, and be reluctant to participate in watershed stewardship planning or action. In such cases, Watershed Habitat Conservation Plans, Safe Harbor Agreements, or other innovative avenues to assure and guarantee private land uses within watersheds should be developed (USFWS, 2005).
- 5. Develop and implement programs to educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship. Only an informed and proactive public can bring about ecosystem stabilization and rehabilitation. Successful ecosystem management will require public involvement, monitoring, and commitment of resources. Educational materials and programs should describe the concept and need for ecosystem management, its long-term economic and environmental advantages, and public and individual stewardship responsibilities (USFWS, 2005).
- 6. Conduct basic research on endemic aquatic species and apply the results toward management and protection of aquatic communities. The biology and ecology of endemic aquatic species in the Basin are poorly known. Information on distribution, habitat requirements, life stage sensitivity to contaminants, and the identification of mussel host fish is essential to the recovery of endemic species and management and protection of their communities and habitats. All partners should be aware of research efforts and results, so that information can be immediately applied. 6.1 Survey and monitor the status of listed and other endemic aquatic species. Extant populations of listed and other endemic species should be located and their status monitored. 6.2 Conduct detailed physical and molecular genetic analyses of endemic species. Most of the Basin's endemic aquatic species have not been fully described anatomically. This information, in conjunction with genetic biochemical comparisons of populations and related species, may provide information important to population management and recovery. 6.3 Determine contaminant sensitivity for each life stage. It is known that juvenile and adult life stages of aquatic fauna may differ in sensitivity to contaminants. The technology and methodology should be developed to determine sub-lethal and lethal levels of pesticides, herbicides, and common contaminants and discharges to listed species and other endemic organisms in the Basin. 6.4 Conduct life history research on endemic species to include reproduction, food habits, age and growth, mortality factors. etc. Life history information may provide insight into past declines, current status of endemic species, weak links in the life cycle, and management guidance for their recovery. 6.41 Determine nutritional requirements of endemic species life stages. It is possible that juvenile forms of many taxa feed on different items than adults. Such requirements may be limiting factors in the survival of these species. Nutritional requirements must be known for successful captive propagation of endemic species (see Task 7) (USFWS, 2005).

- 7. Develop and implement technology for maintaining and propagating endemic species in captivity. Populations of endemic species in the Basin are isolated by large expanses of impounded, or otherwise severely altered, habitat. Maintenance of genetic flow between extant populations, and reintroduction of species to restored habitats, will require human intervention. Populations of many species are currently too low to justify translocation of wild stock between drainages. Captive propagation will be required to produce reintroduction stock if ecosystem restoration is eventually successful (see Task 8). Large numbers of juveniles and adults will also be needed for research to determine sensitivity of species to common contaminants (Task 6.3) (USFWS, 2005)..
- 8. Reintroduce aquatic species into restored habitats, as appropriate. For many listed species, this step will be possible only when, and if, successful captive propagation technology is developed. Reintroduction will be closely coordinated with appropriate State agencies and affected private landowners. No reintroduction or translocation of species should be made without the concurrence of the appropriate State wildlife resource agencies and the knowledge and consensus of local watershed residents. 8.1 Identify sites for translocation/reintroduction. Potential sites for reintroduction consist of streams within the historic range of endemic species that meet the substrate, flow, water quality, and other environmental requirements of the species. Such sites need to be identified and monitored. 8.11 Survey and prioritize potential sites. Water quality, substrate composition, aquatic community composition, and watershed land uses should be characterized. Priority should be given to watersheds with appropriate habitat, diverse faunal assemblages, minimal land use impacts, and active management programs. 8.2 Translocate target endemic species to priority sites. Translocations should be conducted in a rigorous, scientific manner, and should be well-documented. 8.3 Monitor translocated populations. Stream and river reaches with translocated populations should be monitored and surveyed annually for a minimum of 10 years following translocation (USFWS, 2005).
- 9. Monitor listed species population levels and distribution and periodically review ecosystem management strategy. Listed species will be monitored by Tasks 6.1 and 8.3. Changes in distribution (losses and gains) should be used to focus recovery efforts and priorities. Ecosystem management strategy should be periodically reviewed and revised, if appropriate, based on this information (USFWS, 2005).
- 10. Coordinate ecosystem management actions. The above recovery tasks approach ecosystem stabilization and management on three tiers: Federal and State regulatory authority and responsibility; private activities, public education and involvement; and research. Implementation of these tasks will involve multiple partners including State and Federal agencies, municipal and county governments, environmental and recreational organizations, civic groups, educational and research institutions, business and industry groups, landowners, and interested individuals. Successful implementation requires development of partnerships, coordination of on-going activities, determination and prioritization of needed actions, and monitoring recovery progress within each of the Basin's major drainages (USFWS, 2005).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS: • Conduct systematic population monitoring of extant and reintroduced populations of these snails and document potential threats to those populations. • Evaluate the status of the lacy elimia in Emauhee and Weewoka Creeks and confirm that its status in Cheaha Creek remains stable. Also conduct surveys within the Middle Coosa River tributaries that are within the historic range of the species. Results from these studies may suggest a need to upgrade its ESA status from threatened to endangered. • Continue to evaluate the extent and viability of the new populations of cylindrical lioplax within the Little Cahaba River, Yellowleaf Creek, and Choccolocco Creek, in order to determine if it meets the recovery criteria for downlisting to threatened. • Reassess and amend as needed the recovery plan for 6 Mobile River Basin aquatic snails, specifically, the recovery criteria and population criteria for recovery should be evaluated. • Continue to develop and implement habitat restoration plans for the streams where these species occur, or where they can be reintroduced. • Continue assisting the State's propagation studies and efforts. • Work with State agencies, local groups, and individuals to protect and improve water quality in the drainages supporting the six snail species. • Implement all other recovery tasks (USFWS, 2016).

References

U.S. Fish and Wildlife Service. 2005. Recovery Plan for 6 Mobile River Basin Aquatic Snails. U.S. Fish and Wildlife Service, Jackson, Mississippi. pp

USFWS 2006. Cylindrical Lioplax (Lioplax cyclostomaformis), Flat Pebblesnail (Lepyrium showalteri), Plicate Rocksnail (Leptoxis plicata), Painted Rocksnail (Leptoxis taeniata), Round Rocksnail (Leptoxis ampla) and Lacy Elimia (Elimia crenatella) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Ecological Services Jackson, Mississippi

NatureServe Explorer (2015): An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 9, 2016).

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USFWS. 2016. Cylindrical Lioplax (Lioplax cyclostomaformis) Flat Pebblesnail (Lepyrium showalteri) Plicate Rocksnail (Leptoxis plicata) Painted Rocksnail (Leptoxis taeniata) Round Rocksnail (Leptoxis ampla) Lacy Elimia (Elimia crenatella) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office.

SPECIES ACCOUNT: *Lioplax cyclostomaformis* (Cylindrical lioplax (snail))

Species Taxonomic and Listing Information

Listing Status: Endangered; October 28, 1998; Southeast region (R4)

Physical Description

The shell is elongate, reaching about 28 millimeters (mm) (1.1 inches (in)) in length. Shell color is light to dark olivaceous-green externally, and bluish inside of the aperture (shell opening). The cylindrical lioplax is distinguished from other viviparid (eggs hatch internally and the young are born as juveniles) snails in the Basin by the number of whorls, and differences in size, sculpture, microsculpture, and spire angle. No other species of lioplax snails are known to occur in the Mobile Basin (see Clench and Turner, 1955 for a more detailed description) (USFWS, 2005).

Taxonomy

The cylindrical lioplax is a gill-breathing snail in the family Viviparidae (USFWS, 2005).

Historical Range

Collection records for the cylindrical lioplax exist from the Alabama River (Dallas County, Alabama), Black Warrior River (Jefferson County, Alabama) and tributaries (Prairie Creek, Marengo County, Alabama; Valley Creek, Jefferson County, Alabama); Coosa River (Shelby, Elmore counties, Alabama) and tributaries (Oothcalooga Creek, Bartow County, Georgia; CoahuIla Creek, Whitfield County, Georgia; Annuchee Creek, Floyd County, Georgia; Little Wills Creek, Etowah County, Alabama; Choccolocco Creek, Talladega County, Alabama; Yellowleaf Creek, Shelby County, Alabama); and the Cahaba River (Bibb, Shelby counties, Alabama) and its tributary, Little Cahaba River (Jefferson County, Alabama) (Clench and Turner, 1955). A single collection of this species has also been reported from the Tensas River, Madison Parish, Louisiana (Clench, 1962); however, there are no previous or subsequent records outside of the Alabama-Coosa system, and searches of the Tensas River in Louisiana by Service biologists (1995) and others (Vidrine, 1996) have found no evidence of the species or its typical habitat (USFWS, 2005).

Current Range

The cylindrical lioplax is currently known only from approximately 24 kilometers (km) (15 miles (mi)) of the Cahaba River above the Fall Line in Shelby and Bibb counties, Alabama (Bogan and Pierson, 1993b). Survey efforts by Davis (1974) failed to locate this snail in the Coosa or Alabama rivers, and more recent survey efforts have also failed to relocate the species at historic localities in the Alabama, Black Warrior, Little Cahaba, and Coosa rivers and their tributaries (Bogan and Pierson, 1993a, 1993b; M. Pierson, in litt., 1993, 1994; Service Field Records, 1991, 1992, 1993) (USFWS, 2005).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Periphyton is inferred as a food source …'For example, sediments have been shown to abrade and/or suffocate periphyton (organisms attached to underwater surfaces, upon which snails may feed); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters, 1995).' It is believed to filter feed (USFWS, 2005; NatureServe, 2015).

Reproduction Narrative

Adult: It is believed to brood its young, as do other members of the Viviparidae. Life spans have been reported from 3 to 11 years in various species of Viviparidae (Heller, 1990) (USFWS, 2005).

Environmental Specificity

Adult: Narrow/specialist (inferred from USFWS, 2005).

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2005).

Site Fidelity

Adult: High (inferred from USFWS, 2005).

Habitat Narrative

Adult: Habitat for the cylindrical lioplax is unusual for the genus, as well as for other genera of viviparid snails. It lives in isolated mud deposits found under large rocks in the rapid flowing sections of stream and river shoals. Other lioplax species are usually found along the margins of rivers in exposed muddy substrates (USFWS, 2005). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs (inferred from USFWS, 2005).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 2005).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS, 2005).

Dispersal

Adult: Low (inferred from USFWS, 2005).

Immigration/Emigration

Adult: Unlikely (inferred from USFWS, 2005).

Dispersal/Migration Narrative

Adult: Low mobility, non-migratory, low dispersal potential, no immigration/emigration are inferred based on the species specific habitat requirements (inferred from USFWS, 2005).

Population Information and Trends

Population Trends:
Decreasing (NatureServe, 2015)

Resiliency:
Low (inferred from NatureServe, 2015)

Representation:
Low (inferred from NatureServe, 2015)

Redundancy:
Low (inferred from NatureServe, 2015)

Number of Populations:
1 to 5 (NatureServe, 2015)

Population Size:
1-1000 (NatureServe, 2015)

Population Narrative:
Decreasing population trends, population size and number of populations is noted in NatureServe. Resiliency, Representation and Redundancy are inferred based on population size and habitat requirements (USFWS, 2005; NatureServe, 2015).

Threats and Stressors

Stressor: Impoundments (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Dams change such areas by eliminating or reducing currents, and allowing sediments to accumulate on inundated channel habitats. Impounded waters also experience changes in water chemistry which could affect survival or reproduction of riverine snails. For example, many reservoirs in the Basin currently experience eutrophic (enrichment of a water body with nutrients) conditions and chronically low dissolved oxygen levels (Alabama Department of Environmental Management [ADEM], 1994, 1996). Such physical and chemical changes can affect feeding, respiration, and reproduction of these riffle and shoal snail species. In addition to directly altering snail habitats, dams and their impounded waters also formed barriers to the movement of snails that continued to live below dams or in unimpounded tributaries. It is suspected that many such isolated colonies gradually disappear as a result of local water and habitat quality changes. Unable to emigrate (move out of the area), the isolated snail populations are vulnerable to local discharges as well as any detrimental land surface runoff within their watersheds. Although many watershed impacts have been temporary, eventually improving or even disappearing with the advent of new technology, management practices, or laws, dams and their impounded waters prevent natural recolonization by snail populations surviving elsewhere (USFWS, 2005).

Stressor: Water pollution (USFWS, 2005)
Exposure:

Response:
Consequence:
Narrative: Short-term and long-term impacts of point and nonpoint source water and habitat gradation continue to be a primary concern for the survival of all these snails, compounded by their isolation and localization. Point source discharges and land surface runoff (nonpoint pollution) can cause nutrification, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry that are likely to seriously impact aquatic snails. Point sources of water quality degradation include municipal and industrial effluents. Nonpoint source pollution from land surface runoff can originate from virtually all land use activities, and may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and oils and greases (ADEM, 1996). During recent surveys for these snails, sediment deposition and/or dense algal mats (a sign of nutrient pollution of streams) were noted at many historic collection localities where snails had disappeared (Bogan and Pierson, 1993a, 1993b; Hartfield, 1991; Service Field Observations, 1992-1994, Jackson Field Office, MS) (USFWS, 2005).

Stressor: Sedimentation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Excessive sediments are believed to impact riverine snails requiring clean, hard shoal stream and river bottoms, by making the habitat unsuitable for feeding or reproduction. Similar impacts resulting from sediments have been noted for many other components of aquatic communities. For example, sediments have been shown to abrade and/or suffocate periphyton (organisms attached to underwater surfaces, upon which snails may feed); affect respiration, growth, reproductive success, and behavior of aquatic insects and mussels; and affect fish growth, survival, and reproduction (Waters, 1995). Sediment is the most abundant pollutant produced in the Basin (ADEM, 1989). Potential sediment sources within a watershed include virtually all activities that disturb the land surface, and all localities currently occupied by these snails are affected to varying degrees by sedimentation. The amount and impact of sedimentation on snail habitats may be locally correlated with the land use practice, and the degree of implementation of agriculture, forestry, and construction Best Management Practices (USFWS, 2005).

Stressor: Runoff (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Land surface runoff contributes the majority of nutrients to streams in the Mobile River Basin (Atkins et al., 2004). Excessive nutrient input (from fertilizers, sewage waste, animal manure, etc.) can result in periodic low dissolved oxygen levels that are detrimental to aquatic species (Hynes, 1970). Nutrients also promote heavy algal growth that may cover and eliminate clean rock or gravel habitats of shoal dwelling snails. Nutrient and sediment pollution may have synergistic effects (a condition in which the toxic effect of two or more pollutants is much greater than the sum of the effects of the pollutants when operating individually) on freshwater snails and their habitats, as has been suggested for aquatic insects (Waters, 1995) (USFWS, 2005).

Stressor: Waste water treatment (USFWS, 2005)

Exposure:
Response:
Consequence:
Narrative: The cylindrical lioplax, flat pebblesnail, and the round rocksnail currently survive in localized reaches of the Cahaba River drainage. Water quality studies in the upper Cahaba River drainage by the Geological Survey of Alabama (Shepard et al., 1996) found that discharges from 34 waste water treatment plants (WWTPs) in the upper drainage have contributed to water quality impairment. This was reflected by low levels of dissolved oxygen downstream of Birmingham; ammonia and chlorination by-products in excess of recommended water quality criteria; and eutrophication (demonstrated by dense algal mats and nightly sags in dissolved oxygen levels) due to excessive levels of phosphorus and nitrogen. The study noted that these problems are chronic and have been a factor in a loss of mollusk and fish diversity throughout the drainage. Their results indicate that the upper Cahaba River drainage is primarily impacted by nonpoint runoff and WWTPs through physical habitat destruction by sedimentation, and chronic stress from exposure to toxics and low dissolved oxygen. The middle Cahaba River is primarily impacted by eutrophication and associated effects (USFWS, 2005).

Stressor: Predation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Aquatic snails are consumed by various vertebrate predators, including fishes, mammals, and possibly birds. Predation by naturally occurring predators is a normal aspect of the population dynamics of a species and is not considered a threat to these species. However, the potential now exists for black carp (Mylopharyngodon piceus), a nonselective snail eating fish recently introduced into waters of the United States, to eventually enter the Mobile River Basin. Exotic black carp escaped to the Osage River in Missouri when hatchery ponds were flooded during a 1994 spring flood of the river (LMRCC newsletter, 1994). Although black carp have been banned for use in aquaculture in the State of Alabama, they are cultured and sold within the State of Mississippi (D. Reike, Mississippi Department of Wildlife, Fisheries, and Parks, pers. comm., 1997). The extent of stocking black carp for snail control in aquaculture ponds within the Basin is currently unknown (USFWS, 2005).

Recovery

Reclassification Criteria:
The cylindrical lioplax will be considered for reclassification to threatened status when the following criteria are met:

1. The existing population has been shown to be stable or increasing over a period of 10 years (2 to 5 generations). This may be measured by numbers/area, catch per unit/effort, or other methods developed through population monitoring, and must be demonstrated through annual monitoring (USFWS, 2005).

2. There are no apparent or immediate threats to the listed population (see Listing/Recovery Criteria, below) (USFWS, 2005).

3. A captive population has been established at an appropriate facility, and the species has been successfully propagated (USFWS, 2005).

4. A minimum of two additional populations have been established (or discovered) within historic range (USFWS, 2005).

Delisting Criteria:
1. A minimum of 3 natural or re-established populations have been shown to be persistent (i.e., stable or increasing) for a period of 10 years (2 to 5 generations) (USFWS, 2005).

2. There are no apparent or immediate threats to the populations (see Listing/Recovery Factor Criteria, below). A population is defined as all snails occurring within a contiguous river or stream reach extending a minimum of 30 km (18 mi). Snails in a recovered population should be easily found in appropriate habitat throughout the occupied reach (USFWS, 2005).

Recovery Actions:
- The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin. The following recovery tasks are taken from the Mobile River Basin Aquatic Ecosystem Recovery Plan (U.S. Fish and Wildlife Service, 2000). They were developed to support the recovery of all endangered and threatened aquatic species in the Basin (USFWS, 2005).
- 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully

considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control. 1. Protect habitat integrity and quality of river and stream segments that currently support or could support imperiled aquatic species. Stemming the decline and loss of instream aquatic habitats throughout the Basin is essential for maintenance and management of the species and communities these habitats support. River and stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from projects and actions that would adversely affect instream habitats. However, many high quality stream and river reaches currently without known listed populations may contain other unlisted imperiled species, or may be suitable for eventual restocking with listed aquatic species. Providing a higher degree of consideration for such areas will maintain options essential for the successful management of isolated populations within a fragmented ecosystem. Regulatory agencies, municipalities, businesses and industries, and private land owners should thoroughly consider and apply creative alternatives to habitat modification, waste disposal, and other impacts to the aquatic ecosystem. The key to successful recovery planning that minimizes impacts to both listed species and stakeholders is vigilant monitoring and management of remaining instream habitats through informed participation by all stakeholders. 1.1 Identify for protection free flowing stream and river reaches that support high native aquatic biodiversity. Identification brings recognition of special protection needs. River and stream reaches in the Basin that support historically occurring, reproducing endemic species and communities are valuable but diminishing resources and should be recognized by regulatory agencies and given appropriate consideration to mitigate (i.e., avoid, minimize, or compensate for) adverse impacts. 1.2 Minimize aquatic habitat impacts resulting from activities or permits conducted or issued by regulatory authorities. Major habitat modifications that have had the most serious impacts on the aquatic biota of the Basin have been either constructed or authorized by Federal and/or State regulatory agencies. Future modifications for flood control, navigation, water supply, mining, etc. must be fully considered for need and alternatives. Practical alternatives such as floodplain easement purchases, relocation of floodplain structures or activities, protection of headwater wetlands, etc., should be used where and when appropriate. All construction activities permitted or conducted by Federal, State, County, or other local regulatory authority should effectively implement Best Management Practices for stormwater runoff and sediment control (USFWS, 2005).

- 2. Consider options for free-flowing river and stream mitigation strategies that give high priority to avoidance and restoration. As noted above, avoidance of impact is the most important and immediate management need for maintaining existing imperiled populations and their habitats. However, long-term management requires the ability to accommodate changes in human use of the Basin's resources. Restoration of stream and river reaches, and rehabilitation of their aquatic communities will increase management options to accommodate future changes within the Basin. Compensating for aquatic habitat impacts can be an important component of aquatic habitat management. 2. Identify appropriate mitigation measures for free flowing streams and rivers. When destruction or alteration of stream or river habitat is unavoidable, there should be an effort to restore or rehabilitate a comparable amount of instream aquatic habitat elsewhere in the Basin. Unfortunately, there is little guidance or consensus for the amount and degree of measures that could satisfy mitigation goals for free flowing riverine habitat. Federal, State, and local environmental and regulatory agencies and nongovernmental interests must work toward consensus on this problem, considering issues such as amount, quality, and location of river or stream segments under consideration for mitigation measures, and other alternatives, such as the need and possibility of establishing mitigation banks for permit applicants. 2.11 Investigate the potential of partnerships and assistance to relieve land use problems within watersheds as a form of mitigation. Concentrated land uses within watersheds can overwhelm the benefits of individual landowner Best Management Practices (BMPs). Animal wastes from concentrated husbandry of poultry, fish, and livestock is a major determinant of water quality in some watersheds. Urbanization of watersheds also causes complex runoff/water quality problems. Such problem areas may offer creative mitigation opportunities. Examples include developing equipment, facilities, or other components to establish centralized waste treatment for areas of high concentration of poultry farms and other animal feedlots; and providing assistance to communities for stormwater catchment and treatment (USFWS, 2005).

- 3. Promote voluntary stewardship as a practical and economical means of reducing nonpoint pollution from private land use. BMPs can be effective and practical actions identified to prevent or reduce nonpoint pollution from specific land use activities (ADEM, 1989). For example, agricultural BMPs are designed to reduce sediments, animal wastes, fertilizers, and pesticides in stormwater runoff (e.g., Alabama Soil and Water Conservation Committee (ASWCC), 1995). Mining BMPs address sediments and water quality parameters such as acidity and metal concentrations (e.g., ADEM, 1989). Silviculture BMPs include actions to minimize sediments, nutrients, organics, chemicals, and stream canopy removal (e.g., Alabama Forestry Commission, 1993). BMPs are also available for urban, construction, and homeowner activities that address stormwater runoff quality and quantity (ASWCC, 1992, MSDEQ, 1994). BMPs are developed by State and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and State resource agencies should continue to promote and improve BMPs when necessary as a nonregulatory approach to aquatic ecosystem management. 3.1 Work with State and private partners to promote land and water stewardship awareness. Local offices of State and Federal agencies and private organizations can become a primary source of encouragement and information for imperiled species and aquatic ecosystem management. For example, local offices (e.g, Soil and Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commissions, private industry groups, environmental groups, etc.) can identify watersheds with listed species within their areas; inform local landowners of listed species' presence, needs, and special management concerns; recommend appropriate BMPs; and mediate landowner concerns or conflicts with appropriate State and/or Federal agencies. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity. Private industry groups can work with local landowners to customize BMPs where needed to address watershed problems and practices. 3.2 Encourage the development and implementation of adequate Streamside Management Zones (SMZs) along all streams and rivers in the Basin. Properly designed SMZs, which act as filter strips, can buffer the impacts of land use activities on water and stream bottom habitat quality. SMZs protect public and private property from erosion, reduce downstream sedimentation, and enhance fish and wildlife values for both game and nongame species.

SMZs can also reduce nutrient levels in tributary streams in the Basin, which will help control eutrophication in Basin reservoirs (see Part I, Section C in Ecosystem Recovery Plan). Some farmlands adjacent to streams and rivers may qualify for SMZ set aside under the U.S. Department of Agriculture's Conservation Reserve Program and other initiatives. SMZs are widely recognized as cost effective habitat management practices. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. SMZs may be custom designed to protect stream habitat while achieving individual landowners management objectives. For example, the Natural Resources Conservation Service recommends SMZs from 22 to 91 meters (75 to 300 feet), with varying restrictions, depending on soil, slope, topography, and land use. Other government agencies and private groups make similar recommendations. SMZs are also effective in controlling urban and suburban stormwater runoff (USFWS, 2005).

- 4. Encourage and support community based watershed stewardship planning and action. Protection, restoration, and management planning for imperiled aquatic habitats is best accomplished by partners and stakeholders within a watershed. Such grassroots community planning educates participants about aquatic species, their habitat needs, and sensitivities; acknowledges local activities, problems and their effects on water; and leads to consensus based local solutions. Stewardship partnerships are essential in watersheds supporting listed or other imperiled aquatic species, and should be encouraged within any of the Basin's watersheds. Resource and regulatory agencies should offer support, materials, and technical and facilitation assistance when requested. 4.1 Reduce private land use/endangered species conflicts. Landowners and other watershed residents may feel threatened by the presence of listed aquatic species, and be reluctant to participate in watershed stewardship planning or action. In such cases, Watershed Habitat Conservation Plans, Safe Harbor Agreements, or other innovative avenues to assure and guarantee private land uses within watersheds should be developed (USFWS, 2005).
- 5. Develop and implement programs to educate the public on the need and benefits of ecosystem management, and to involve them in watershed stewardship. Only an informed and proactive public can bring about ecosystem stabilization and rehabilitation. Successful ecosystem management will require public involvement, monitoring, and commitment of resources. Educational materials and programs should describe the concept and need for ecosystem management, its long-term economic and environmental advantages, and public and individual stewardship responsibilities (USFWS, 2005).
- 6. Conduct basic research on endemic aquatic species and apply the results toward management and protection of aquatic communities. The biology and ecology of endemic aquatic species in the Basin are poorly known. Information on distribution, habitat requirements, life stage sensitivity to contaminants, and the identification of mussel host fish is essential to the recovery of endemic species and management and protection of their communities and habitats. All partners should be aware of research efforts and results, so that information can be immediately applied. 6.1 Survey and monitor the status of listed and other endemic aquatic species. Extant populations of listed and other endemic species should be located and their status monitored. 6.2 Conduct detailed physical and molecular genetic analyses of endemic species. Most of the Basin's endemic aquatic species have not been fully described anatomically. This information, in conjunction with genetic biochemical comparisons of populations and related species, may provide information important to population management and recovery. 6.3 Determine contaminant sensitivity for each life stage. It is known that juvenile and adult life stages of aquatic fauna may differ in sensitivity to contaminants. The technology and methodology should be developed to determine sub-

lethal and lethal levels of pesticides, herbicides, and common contaminants and discharges to listed species and other endemic organisms in the Basin. 6.4 Conduct life history research on endemic species to include reproduction, food habits, age and growth, mortality factors. etc. Life history information may provide insight into past declines, current status of endemic species, weak links in the life cycle, and management guidance for their recovery. 6.41 Determine nutritional requirements of endemic species life stages. It is possible that juvenile forms of many taxa feed on different items than adults. Such requirements may be limiting factors in the survival of these species. Nutritional requirements must be known for successful captive propagation of endemic species (see Task 7) (USFWS, 2005).

- 7. Develop and implement technology for maintaining and propagating endemic species in captivity. Populations of endemic species in the Basin are isolated by large expanses of impounded, or otherwise severely altered, habitat. Maintenance of genetic flow between extant populations, and reintroduction of species to restored habitats, will require human intervention. Populations of many species are currently too low to justify translocation of wild stock between drainages. Captive propagation will be required to produce reintroduction stock if ecosystem restoration is eventually successful (see Task 8). Large numbers of juveniles and adults will also be needed for research to determine sensitivity of species to common contaminants (Task 6.3) (USFWS, 2005)..
- 8. Reintroduce aquatic species into restored habitats, as appropriate. For many listed species, this step will be possible only when, and if, successful captive propagation technology is developed. Reintroduction will be closely coordinated with appropriate State agencies and affected private landowners. No reintroduction or translocation of species should be made without the concurrence of the appropriate State wildlife resource agencies and the knowledge and consensus of local watershed residents. 8.1 Identify sites for translocation/reintroduction. Potential sites for reintroduction consist of streams within the historic range of endemic species that meet the substrate, flow, water quality, and other environmental requirements of the species. Such sites need to be identified and monitored. 8.11 Survey and prioritize potential sites. Water quality, substrate composition, aquatic community composition, and watershed land uses should be characterized. Priority should be given to watersheds with appropriate habitat, diverse faunal assemblages, minimal land use impacts, and active management programs. 8.2 Translocate target endemic species to priority sites. Translocations should be conducted in a rigorous, scientific manner, and should be well-documented. 8.3 Monitor translocated populations. Stream and river reaches with translocated populations should be monitored and surveyed annually for a minimum of 10 years following translocation (USFWS, 2005)..
- 9. Monitor listed species population levels and distribution and periodically review ecosystem management strategy. Listed species will be monitored by Tasks 6.1 and 8.3. Changes in distribution (losses and gains) should be used to focus recovery efforts and priorities. Ecosystem management strategy should be periodically reviewed and revised, if appropriate, based on this information (USFWS, 2005).
- 10. Coordinate ecosystem management actions. The above recovery tasks approach ecosystem stabilization and management on three tiers: Federal and State regulatory authority and responsibility; private activities, public education and involvement; and research. Implementation of these tasks will involve multiple partners including State and Federal agencies, municipal and county governments, environmental and recreational organizations, civic groups, educational and research institutions, business and industry groups, landowners, and interested individuals. Successful implementation requires

development of partnerships, coordination of on-going activities, determination and prioritization of needed actions, and monitoring recovery progress within each of the Basin's major drainages (USFWS, 2005).

Conservation Measures and Best Management Practices:

- RECOMMENDATION FOR FUTURE ACTIONS: • Conduct systematic population monitoring of extant and reintroduced populations of these snails and document potential threats to those populations. • Evaluate the status of the lacy elimia in Emauhee and Weewoka Creeks and confirm that its status in Cheaha Creek remains stable. Also conduct surveys within the Middle Coosa River tributaries that are within the historic range of the species. Results from these studies may suggest a need to upgrade its ESA status from threatened to endangered. • Continue to evaluate the extent and viability of the new populations of cylindrical lioplax within the Little Cahaba River, Yellowleaf Creek, and Choccolocco Creek, in order to determine if it meets the recovery criteria for downlisting to threatened. • Reassess and amend as needed the recovery plan for 6 Mobile River Basin aquatic snails, specifically, the recovery criteria and population criteria for recovery should be evaluated. • Continue to develop and implement habitat restoration plans for the streams where these species occur, or where they can be reintroduced. • Continue assisting the State’s propagation studies and efforts. • Work with State agencies, local groups, and individuals to protect and improve water quality in the drainages supporting the six snail species. • Implement all other recovery tasks (USFWS, 2016).

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SPECIES ACCOUNT: *Newcombia cumingi* (Newcomb's Tree snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 06/27/2013; Pacific Region (R1) (USFWS, 2016)

Physical Description

Newcomb's tree snail reaches an adult length of approximately 0.8 in (21 mm) and its shell is mottled in shades of brown that blend with the bark of its native host plant, Metrosideros polymorpha (ohia) (Pilsbry and Cooke 1912-1914, p. 10; Thacker and Hadfield 1998, p. 4) (USFWS, 2013).

Taxonomy

Newcomb's tree snail (Newcombia cumingi), a member of the family Achatinellidae and the endemic Hawaiian subfamily Achatinellinae (Newcomb 1853, p. 25), is known only from the island of Maui (Cowie et al. 1995, p. 62) (USFWS, 2016).

Historical Range

Historically, this species was distributed from the west Maui mountains (near Lahaina and Wailuku) to the slopes of Haleakala (Makawao) on east Maui (Pilsbry and Cooke 1912-1914, p. 10) (USFWS, 2013).

Current Range

In 1994, a small population of Newcomb's tree snail was found on a single ridge on the northeastern slope of the west Maui mountains, in the lowland wet ecosystem (Thacker and Hadfield 1998, p. 3; TNC 2007) (USFWS, 2013).

Critical Habitat Designated

Yes; 3/30/2016.

Legal Description

On March 30, 2016, the U.S. Fish and Wildlife Service designated critical habitat for Newcombia cumingi.

Critical Habitat Designation

Critical habitat for Newcomb's tree snail is designated in Unit 1— Lowland Wet-Maui, Maui County, Hawaii (65 ac, 26 ha).

Unit 1—Lowland Wet. This area consists of 65 ac (26 ha) of State land at Moomoku, on the northwestern slopes of west Maui. These units include the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the lowland wet ecosystem. These units are occupied by the plant Santalum haleakalae var. lanaiense.

Primary Constituent Elements/Physical or Biological Features

The critical habitat unit is designated for Maui County, Hawaii. In unit 1, the primary constituent elements of critical habitat for the Newcomb's tree snail are:

(i) Elevation: Less than 3,300 ft (1,000 m).

(ii) Annual precipitation: Greater than 75 in (190 cm).

(iii) Substrate: Clays; ashbeds; deep, well-drained soils; lowland bogs.

(iv) Canopy: Antidesma, Metrosideros, Myrsine, Pisonia, Psychotria.

(v) Subcanopy: Cibotium, Claoxylon, Kadua, Melicope.

(vi) Understory: Alyxia, Cyrtandra, Dicranopteris, Diplazium, Machaerina, Microlepia.

Special Management Considerations or Protections

Existing manmade features and structures, such as buildings, roads, railroads, airports, runways, other paved areas, lawns, and other urban landscaped areas, do not contain one or more of the physical or biological features. Federal actions limited to those areas, therefore, would not trigger a consultation under section 7 of the Act unless they may affect the species or physical or biological features in adjacent critical habitat.

The overall recovery of this species includes protection of existing populations and habitat, augmentation of existing populations and reestablishment of new populations within the historical range, control of threats, research on species biology and ecology, and research on abatement and control of threats that are currently not addressed. Relevant to this designation of critical habitat, the recovery of these 135 Hawaiian species therefore requires a combination of both presently occupied habitat (to protect existing populations) and unoccupied habitat (for expansion or augmentation of existing populations and reestablishment of new populations within the historical range).

The primary threats to the physical or biological features essential to the conservation ofthis species include habitat destruction and modification by nonnative ungulates, competition with nonnative species, hurricanes, landslides, rockfalls, flooding, fire, drought, and climate change. Additionally, the rosy wolf snail poses a threat to the Newcomb's tree snail. All designated critical habitat requires active management to address the ongoing degradation and loss of native habitat caused by nonnative ungulates (pigs, goats, mouflon sheep, axis deer, and cattle). Nonnative ungulates also impact the habitat through predation and trampling. Without this special management, habitat containing the features that are essential for the conservation of this species will continue to be degraded and destroyed.

Life History

Feeding Narrative

Adult: It feeds on fungi and algae that grow on the leaves and trunks of its host plant (Pilsbry and Cooke 1912-1914, p. 103) (USFWS, 2013).

Reproduction Narrative

Adult: The exact life span and fecundity of the Newcomb's tree snail is unknown, but they attain adult size within 4 to 5 years (Thacker and Hadfield 1998, p. 2). Newcomb's tree snail is believed to exhibit the low reproductive rate of other Hawaiian tree snails belonging to the same family (Thacker and Hadfield 1998, p. 2) (USFWS, 2013).

Environmental Specificity

Adult: Narrow/specialist (inferred from USFWS, 2013)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2013)

Site Fidelity

Adult: High (inferred from USFWS, 2013)

Habitat Narrative

Adult: In 1994, a small population of Newcomb's tree snail was found on a single ridge on the northeastern slope of the west Maui mountains, in the lowland wet ecosystem (Thacker and Hadfield 1998, p. 3; TNC 2007) (USFWS, 2013). Clumped spatial arrangements of the population, narrow environmental specificity, high ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the specific habitat requirements of the species and the fact that there is only one knnwon population with (at last count) only one known individual.

Dispersal/Migration

Population Information and Trends

Population Trends:

Decreasing (USFWS, 2013)

Resiliency:

Low (inferred from USFWS, 2013)

Representation:

Low (inferred from USFWS, 2013)

Redundancy:

Low (inferred from USFWS, 2013)

Number of Populations:

1 (USFWS, 2013)

Population Size:

One (USFWS, 2013)

Population Narrative:

Species was considered extirpated untile 1994 when a small population of Newcomb's tree snail was found on a single ridge on the northeastern slope of the west Maui mountains, in the lowland wet ecosystem (Thacker and Hadfield 1998, p. 3; TNC 2007). Eighty-six snails were documented in the same location in 1998; in 2006, only nine individuals were located; and, in

2012, only one individual was located (Thacker and Hadfield 1998, p. 2; Hadfield 2007, p. 8; Higashino 2013, in litt.) (USFWS, 2013). Low resiliency, representation and redundancy are based on the fact that there is only one known population with (at last count) only one known individual.

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Adverse impacts on habitat of this species have been identified from nonnative plants, drought, and hurricanes. The effects of nonnative plants on native plant species include competition and displacement; competition may be for water, light, or nutrients, or it may involve allelopathy (chemical inhibition of other plants). Drought Hurricanes adversely impact native Hawaiian terrestrial habitat by destroying native vegetation, opening the canopy and thus modifying the availability of light, and creating disturbed areas conducive to invasion by nonnative pest species. Hurricanes adversely impact native Hawaiian terrestrial habitat by destroying native vegetation, opening the canopy and thus modifying the availability of light, and creating disturbed areas conducive to invasion by nonnative pest species. Potential adverse impacts from climate change have also been identified (USFWS, 2013).

Stressor: Overutilization (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The Hawaiian tree snails are vulnerable to the impacts of overutilization due to collection for trade or market (USFWS, 2013).

Stressor: Disease or predation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Disease is a potential threat to this tree snail, as recovery of this species likely will include captive propagation and disease is suspected to be a cause of currently unsuccessful captive propagation. However, the Services have no evidence to suggest that disease is acting on the wild populations such that it may be considered a significant threat to the species. Predation and herbivory by nonnative species (rats, Jackson's chameleon, flatworms (potentially), and snails) is considered an ongoing threat through the species range (USFWS, 2013).

Stressor: Small populations (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Newcombia cumingi faces the threat of limited numbers (i.e., there are fewer than 50 individuals in the wild). Newcombia cumingi is known only from a single wild population of one individual and has not been successfully maintained in captivity. The only known wild

populations face serious threats from predation by nonnative rats, Jackson's chameleons, and snails (USFWS, 2013)

Recovery

Recovery Actions:

- A recovery plan has not been initiated for this species.

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SPECIES ACCOUNT: *Orthalicus reses (not incl. nesodryas)* (Stock Island tree snail)

Species Taxonomic and Listing Information

Listing Status: Threatened; Southeast Region (R4) (USFWS, 2015)

Physical Description

The Stock Island tree snail was first described in 1830 based on a snail likely collected from Key West (Say 1830). That specimen was lost and the species was later described by Pilsbry (1946) using a snail from Stock Island. The Stock Island tree snail is a subspecies in the genus Orthalicus. Pilsbry wrote that he believed Orthalicus (Subfamily Orthalicinae) migrated through tropical America on floating trees that were later blown ashore although he provides no specific evidence of this phenomenon. Pilsbry (1946) described the Stock Island tree snail as having a shell that "...is rather thin and light, less solid than [other] races of [Orthalicus]. White to warm buff, this tint deepening near the lip or behind the later varices; stripes...purplish brown, running with the growth-lines, the stripes and the streaks often interrupted between the bands, and mostly not extending below the Lower one; growth-rest varices usually 2 to 4 on the last whorl; three spiral banks, the Upper and Lower interrupted, are indicated, but weaken with age. Apex white, aperture showing the varices, bands and streaks vividly inside; columella white, straightened above; parietal callus white or dilute chestnut in old shells. The characteristics that most distinguish this species from O. reses nesodryas are the white apex and white columella and parietal callus. These characteristics are chestnut-brown or darker in O. reses nesodryas."

Taxonomy

Contains two subspecies, which may now be interbreeding because of human manipulation. (NatureServe, 2015)

Historical Range

See Current

Current Range

Key West Botanical Park in Stock Island, Monroe County, Florida, USA, was last known population from historic range but it went extinct in 1992 (Forys et al., 2001). Formerly occurred on Key West, but disappeared from there after 1938. Several introduced colonies occur further north on the mainland, but these are beyond historic range. (NatureServe, 2015). Historically, Stock Island tree snails occurred only on Stock Island and Key West. Although populations of snails now occur throughout the Keys in hardwood hammocks, the majority of suitable habitat remains unoccupied. As of 2006, a tabulation of all well-known and poorly documented sites indicated that Stock Island tree snails occupied approximately 27 sites, 25 sites in the Florida Keys (Monroe County) and two sites on the mainland (Miami-Dade County). However, for many of those sites, confirmation as to whether Stock Island tree snails persist in recent years is lacking. Populations in the northern Keys are believed to have been distributed by collectors. Snails feed on epiphytic growth on hardwood tree trunks, branches and leaves. The Stock Island tree snail survives best in hammocks of native trees that support relatively large amounts of lichens and algae. In the Keys, Orthalicus is limited to those portions of the islands that have minimum elevations of 5 to 11 feet.

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Little is known about the feeding habits or food preferences of the Stock Island tree snail. Probable food items include a large variety of fungi, algae, and lichens found on many of the native hammock trees. Mixobacteria and some small mites may serve as a secondary food source. Feeding can occur anytime during the day or night with peak feeding activity occurring from late afternoon through the night to mid-morning and during or immediately after rainfall. Feeding Stock Island tree snails often follow a random twisting path that covers the entire bark surface, but will move in a straight line if surface moisture is abundant.

Reproduction Narrative

Adult: The snails are hermaphroditic, but cross-fertilization appears to be common. They mate and nest in late summer and early fall during the wettest part of the rainy season. They lay about 15 eggs per clutch in a cavity dug into the soil humus layer, usually at the base of a tree, and take anywhere from 24 to 105 hours to deposit their eggs (Deisler 1987, McNeese 1989). The eggs hatch during the onset of the rains the following spring. The Stock Island tree snails immediately proceeded upon hatching to climb adjacent trees. Most nesting snails appear to be about 2 to 3 years old. They may live for up to 6 years, with 2.11 years being the mean age for the Stock Island population at the time of Deisler's study (1987). The Stock Island tree snail's age can be estimated by counting the number of dark "suture-like" lines resulting from pigment deposition during long dry spells (the dry season).

Habitat Narrative

Adult: Larger trees support more Stock Island tree snails than smaller trees because they provide the snails with an increased surface area for foraging (Deisler 1987). There is no evidence that Stock Island tree snails prefer certain tree types or species (Deisler 1987). However, Voss (1976) wrote that the tree snails generally prefer trees with smooth bark to trees with rough bark, because the snails would require less energy to crawl over smooth bark. He also believed Stock Island tree snails would prefer smooth bark because it would make it easier for them to form a secure mucous seal when they were aestivating, resulting in lower mortalities from dehydration or accidental dislodgement. Stock Island tree snails are arboreal except when they move to the forest floor for nesting or traveling. Hammocks that contain organic soils or leaf litter are probably necessary for nesting activity and dispersal. No data are available on minimal hammock size needed to support a viable population of tree snails. Suitable habitat would have to include an area large enough to provide for foraging and nesting requirements as well as provide for the microclimate (air temperature and humidity) needed by the Stock Island tree snail. Behavior: The Stock Island tree snails are active mainly during the wet season. Besides the reproductive activities discussed above, most of the feeding and dispersion takes place during the wet season (May through November). Dry periods (usually December through April) are spent in aestivation in which the Stock Island tree snail forms a tight sealed barrier between the aperture and a tree trunk or branch. Snails may come out of aestivation briefly to feed during dry-season rains or go into aestivation during summer dry spells.

Dispersal/Migration

Population Information and Trends

Number of Populations:

27

Population Narrative:

Population Size: Enthusiasts and collectors have introduced Stock Island tree snails to new areas and it is believed that other, unknown, populations exist. Today, populations of snails are found throughout the Keys in hardwood hammocks. The Service has current records of 27 populations, 25 in the Florida Keys and 2 in mainland Miami-Dade County. Population Variability: The snails are hermaphroditic, but cross-fertilization appears to be common. They mate and nest in late summer and early fall during the wettest part of the rainy season. They lay about 15 eggs per clutch in a cavity dug into the soil humus layer, usually at the base of a tree, and take anywhere from 24 to 105 hours to deposit their eggs (Deisler 1987, McNeese 1989). The eggs hatch during the onset of the rains the following spring. The Stock Island tree snails immediately proceeded upon hatching to climb adjacent trees. Most nesting snails appear to be about 2 to 3 years old. They may live for up to 6 years, with 2.11 years being the mean age for the Stock Island population at the time of Deisler’s study (1987). The Stock Island tree snail’s age can be estimated by counting the number of dark “suture-like” lines resulting from pigment deposition during long dry spells (the dry season). Population Size: Enthusiasts and collectors have introduced Stock Island tree snails to new areas and it is believed that other, unknown, populations exist. Today, populations of snails are found throughout the Keys in hardwood hammocks. The Service has current records of 27 populations, 25 in the Florida Keys and 2 in mainland Miami-Dade County. Population Variability: The snails are hermaphroditic, but cross-fertilization appears to be common. They mate and nest in late summer and early fall during the wettest part of the rainy season. They lay about 15 eggs per clutch in a cavity dug into the soil humus layer, usually at the base of a tree, and take anywhere from 24 to 105 hours to deposit their eggs (Deisler 1987, McNeese 1989). The eggs hatch during the onset of the rains the following spring. The Stock Island tree snails immediately proceeded upon hatching to climb adjacent trees. Most nesting snails appear to be about 2 to 3 years old. They may live for up to 6 years, with 2.11 years being the mean age for the Stock Island population at the time of Deisler’s study (1987). The Stock Island tree snail’s age can be estimated by counting the number of dark “suture-like” lines resulting from pigment deposition during long dry spells (the dry season). Rangewide Trends: McNeese (1997) concluded that the Stock Island tree snail was extinct on Stock Island. However, snails were observed there 2 years ago in the botanical garden (Hughes, personal communication, 2006). Recently, a new population was discovered in Key Largo. At least three populations now exist in South Key Largo. Viable populations are apparently successful in North Key Largo. Today, populations of snails occur throughout the Keys in hardwood hammocks. The Service has current records of 27 populations, which many believed to be populations distributed by collectors.

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: The greatest threat to the Stock Island tree snail is the loss and modification of its habitat, although natural disasters such as hurricanes and drought can have a significant effect. The snails are also faced with predation by invertebrate predators, such as fire ants. Forys et al. (2001) used Florida tree snails (Liguus fasciatus) as a surrogate for Stock Island tree snails to assess vulnerability to fire ant predation. In laboratory trials, 19 out of 22 tree snails were killed by the fire ants within 3 days, some while foraging and others while aestivating. Opossums (Didelphis virginiana) and raccoons (Procyon lotor) are known to prey upon both Orthalicus and Liguus snails (Voss 1976, Deisler 1987). Iguanas have also been documented to feed upon tree snails (Townsend et al. 2005). The dynamics of sea level rise coupled with hurricane surge are a significant threat to the Stock Island tree snail. Ish-Shalom et al. (1992) suggest that remaining tropical hardwood hammocks in the lower keys will succeed to mangrove communities. This succession trend for the middle and upper keys is suggested also by Sternberg et al. (2007) and Su Yean Teh et al. (2008). LaFever et al. (2007) and Ross et al. (2009) in their analysis of endemic species in the lower Florida Keys, conclude that as sea level rises and habitats critical to the survival of the species is lost, management actions must include translocation to suitable recipient sites elsewhere.

Recovery

References

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SPECIES ACCOUNT: *Ostodes strigatus* (No common name)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/24/2016; Pacific Region (R1) (USFWS, 2017)

Physical Description

Ostodes strigatus, a light tan- to cream-colored tropical ground-dwelling snail. Ostodes strigatus has a white, turbinate (depressed conical) shell with 4 to 5 whorls and distinctive parallel ridges, reaching a size of 0.3 to 0.4 in (7 to 11 mm) in height, 0.4 to 0.5 in (9 to 12 mm) in diameter at maturity (Girardi 1978, pp. 222–223; Abbott 1989, p. 43). Its operculum is acutely concave to cone-shaped, with broad, irregular spirals from center to edge (Girardi 1978, pp. 198, 213, 222–224). True radial patterning is seldom found on the upper shell surface, and never on the ventral surface, which is usually entirely smooth (Girardi 1978, p. 223) (USFWS, 2016).

Taxonomy

The sisi snail (Ostodes strigatus) is in the superfamily Cyclophoroidea and the family Poteriidae (=Neocyclotidae), a family of tropical land snails with a pallium cavity (lung-like organ) and an operculum (Cowie 1998; Vaught 1989; Barker 2001). The sisi snail is a member of the family Poteriidae, which occurs through tropical Central and South America. The genera Ostodes and Gassiesia are confined to the islands of the South Pacific. All members of the family are ground-dwelling snails (Girardi 1978; Abbott 1989). Girardi (1978) and Cowie (1998) are the most recent and accepted taxonomic work for this species.

Historical Range

The sisi has only been known from the island of Tutuila, American Samoa (Miller 1993).

Current Range

During a survey of snails in American Samoa (Miller 1993), fewer than 50 live snails were seen; all of these were in Maloata Valley at 121-400 ft (37-122 m) in elevation) on the western end of the island of Tutuila, American Samoa. The snails were found to be highly scattered in the leaf litter on the forest floor under an intact canopy of 32-49 ft (10-15 m) above the ground. Several live predatory, rosy carnivore snails (Euglandina rosea) were found in the same area, and the ground was littered with the shells of dead sisi snails. Shells of dead sisi snails were found at four of the eight survey sites in Maloata Valley including the site with live sisi snails.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: The sisi snail is a ground-dwelling snail that feeds on decaying leaf litter and fungus (Girardi 1978).

Reproduction Narrative

Adult: It is likely that adults deposit eggs into leaf litter where they develop and hatch.

Geographic or Habitat Restraints or Barriers

Adult: restricted to suitable habitat

Environmental Specificity

Adult: Generalist

Tolerance Ranges/Thresholds

Adult: Unknown

Site Fidelity

Adult: likely high to moderately high

Dependency on Other Individuals or Species for Habitat

Adult: unknown

Habitat Narrative

Adult: The sisi snail is found on the ground in rocky areas at lower elevations. The vegetation is characterized by a relatively closed canopy with light understory plant coverage. While these areas (below 500 feet (ft) (152 meters (m) elevation) receive moderate to high rainfall, they are drier and more open than the wet forests found at higher elevation or along the northern sections of coastline (Miller 1993).

Dispersal/Migration

Motility/Mobility

Adult: low to moderately low

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory

Dispersal

Adult: low to moderately low

Immigration/Emigration

Adult: Not likely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Adult: probably not applicable

Dispersal/Migration Narrative

Adult: No information is available for this snail. Presumably, it does not move great distances compared to other wildlife.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Resiliency:
low

Representation:
low

Redundancy:
low

Population Growth Rate:
Unknown

Number of Populations:
1 to 4

Population Size:
Unknown

Minimum Viable Population Size:
Unknown

Resistance to Disease:
Unknown

Adaptability:
low

Population Narrative:
Fewer than 50 live snails were seen in Maloata Valley (Miller 1993).

Threats and Stressors

Stressor: Habitat loss and degradation
Exposure:
Response:
Consequence:
Narrative: The declines of the native snails in American Samoa have resulted, in part, from significant loss of native habitat to forestry and agriculture, loss of native forest structure to hurricanes, and the establishment of alien weeds after these storms. These threats may interact to greatly exacerbate the loss of populations and species. All live sisi snails have been found in the leaf litter beneath remaining intact forest canopy. No snails were found in areas bordering agricultural plots or in forest areas that were severely damaged by three hurricanes (1987, 1990,

and 1991) (Miller 1993). Under natural historic conditions, loss of forest canopy to storms did not pose a great threat to the long term survival of these snails; enough intact forest with healthy populations of snails would support dispersal back into newly regrown canopy forest. However, the presence of alien weeds such as Mikania micrantha (mile-a-minute vine) may reduce the likelihood that native forest will re-establish in areas damaged by the hurricanes (Whistler 1992). This loss of habitat to storms is greatly exacerbated by an expanding agriculture needed to support one of the worlds highest human population growth rates (Craig et al. 1993). Agricultural plots have spread from low elevation up to middle and some high elevations on Tutuila, greatly reducing the forest area and thus reducing the resilience of native forests and their populations of native snails. These reductions also increase the likelihood that future storms will lead to the extinction of populations or species that rely on the remaining canopy forest.

Stressor: Invasive predators
Exposure:
Response:
Consequence:
Narrative: At present, the major existing threat to long-term survival of the native snail fauna in American Samoa is predation by the alien rosy carnivore snail, the most commonly recommended biological control agent of the giant African snail (Achatina fulica). Numerous studies show that the rosy carnivore snail feeds on endemic island snails and is a major agent in their declines and extinctions (van der Schalie 1969; Hart 1978; Hadfield and Mountain 1981; Howarth 1983, 1985, 1991; Clarke et al. 1984; Pointier and Blanc 1984; Hadfield 1986; Murray et al. 1988; Hadfield et al. 1989, 1993; Kinzie 1992; Cowie 2001). In an effort to eradicate the giant African snail, the rosy carnivore snail and another alien predatory snail, Gonaxis kibweziensis (no common name), were introduced in 1980 and 1977, respectively (Eldredge 1988). The rosy carnivore snail has spread throughout the main island of Tutuila and has also spread to the island of Tau (Eldredge 1988). G. kibweziensis is present only on Tutuila and seems to be in decline (Eldredge 1988). Several live rosy carnivore snails were found in the same type of habitat in which the sisi snail occurs, and the ground was littered with the shells of dead sisi snails (Miller 1993). The rosy carnivore snail is also a host to the rat lung worm, a parasite (Mead 1961; van der Schalie 1969). It is not known if the parasite can be maintained in populations of native snails or if a parasite load would have negative effects on snail reproduction. In addition, a likely threat to the sisi snail is the high probability of the spread of the predatory Manokwar flatworm, Platydemus manokwari, into occupied snail habitat. The Manokwar flatworm has contributed to the decline of native tree snails due to its ability to ascend into trees and bushes that support native snails. Areas with populations of the flatworm usually lack partulid tree snails or have declining numbers of snails (Hopper and Smith 1992). The predatory flatworm currently occurs on Tutuila; however, it has not been confirmed to occur in areas occupied by the sisi snail (Tulafono 2006, pers. comm.).

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: Currently, no formal or informal protection is given to the sisi snail by the Federal or American Samoa governments or by private individuals or groups.

Stressor: Fragmented/Isolated Populations

Exposure:
Response:
Consequence:
Narrative: Even if the threats responsible for the decline of this species were controlled, the persistence of existing populations is hampered by the small number of extant populations and the small geographic range of known populations. This circumstance makes the species more vulnerable to extinction due to a variety of natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Pimm et al. 1988; Center for Conservation Biology 1994; Mangel and Tier 1994). Stochastic environmental events, like severe storms, can affect the continued existence of the sisi snail due to the small numbers of populations and individuals that remain.

Stressor: Climate change (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: Increased ambient temperature and precipitation and increased severity of hurricanes would likely exacerbate other threats to this species as well as provide additional stresses on its habitat. The probability of species extinction as a result of climate change impacts increases when its range is restricted, habitat decreases, and numbers of populations decline (IPCC 2007, p. 48). Ostodes strigatus is limited by its restricted range in one portion of Tutuila and small population size (USFWS, 2016).

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- Conduct extensive surveys for sisi snail
- Develop and implement nonnative snail removal and control program
- Confirm presence of nonnative predatory flatworm in areas occupied by sisi snail and develop and implement nonnative flatworm control program
- Conduct habitat restoration and control and remove nonnative plant species

Conservation Measures and Best Management Practices:
- Not available

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U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/19/2017

SPECIES ACCOUNT: *Partula gibba* (Humped tree snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2015; Pacific Region (R1) (USFWS, 2016)

Physical Description

The shell of the humped tree snail (Partula gibba) was described by Pilsbry (1909-1910) as conic-ovate, perforate, rather solid, striatulate, pellucid, engraved longitudinally with equal lines, white or flesh-colored, the spire acute, rose-red, the suture milk-white; epidermis thin and refescent. Whorls 4 ½, the last swollen, gibbous, larger than the rest. Aperture long-ovate, subquad-rangular; peristome reflexed, broadly dilated, white. Var. ruddy-black.

Taxonomy

The genus Partula has four species found only in the Mariana Islands, and 94 additional species recorded from other Pacific islands (Cowie 1992). The humped tree snail was first collected on Guam in 1819 by Quoy and Gaimard during the Freycinet Uranie expedition of 1817-1819 (Crampton 1925). Cramptons 1925 taxonomic work is the most recent and accepted taxonomy for this species; however, David Sischo, a graduate student at the University of Hawaii at Manoa, proposes that there are four subspecies of Partula gibba (Sischo, in litt. 2011). Using mitochondrial markers, Sischo determined that there may be four genetically distinct subspecies of Partula gibba: P. gibba ssp. guamensis (Guam), P. gibba ssp. saipanensis (Saipan), P. gibba ssp. sariganensis (Sarigan), and P. gibba ssp. pagonensis (Pagan). In addition, Sischos data suggests the population of P. gibba on Rota is actually a different species.

Historical Range

The three genera and 123 tree snail species of the family Partulidae are restricted to the high-elevation Pacific islands of Polynesia (excluding Hawaii), Melanesia, and Micronesia (Cowie 1992; Paulay 1994). The Mariana archipelago historically supported five species of partulid tree snails, and represents the northwestern limit of the geographical range of the Partulidae. The humped tree snail is the most widely distributed tree snail in the Mariana Islands and was known from Guam, Rota, Aguiguan, Tinian, Saipan, Anatahan, Sarigan, Alamagan, and Pagan. Upon its discovery, this snail was considered to be the most common tree snail on Guam, occupying the branches of trees in cool and shaded habitats (Crampton 1925).

Current Range

According to Sischo (in litt. 2011,), the humped tree snail is found on the islands of Guam, Saipan, Sarigan, and Pagan. Sischos data also suggests that the individuals identified as humped tree snails on Rota maybe a different species. Sischos findings have not been published, and data on population numbers and number of individuals has not been determined. Other data suggests there are 14 known populations on 7 islands: Guam, Rota, Aguiguan, Saipan, Sarigan, Alamagan, and Pagan. This species is likely no longer extant on Tinian and, due to volcanic activity from 2003-2005, is possibly extirpated from Anatahan.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: The snails are generally nocturnal, living on bushes or trees and feeding primarily on senescent or decaying plant material.

Reproduction Narrative

Adult: The biology of the partulid tree snails of the Mariana Islands has not been studied in detail. However, general information on the biology of closely related partulid tree snails has been published and reviewed by Cowie (1992), and the biology of all these species is very similar. As with all terrestrial pulmonate (having lungs or lung-like organs) snails, the Mariana Islands tree snails are hermaphroditic. In general, partulid snails begin reproducing in less than 12 months and may live up to 5 years. Up to 18 young are produced each year and some species may be self-fertile. While most terrestrial snails lay eggs, the partulid tree snails give birth to live young.

Spatial Arrangements of the Population

Adult: clumped according to suitable habitat

Tolerance Ranges/Thresholds

Adult: unknown

Habitat Narrative

Adult: The humped tree snail prefers cool, shaded forest habitats (Crampton 1925; Cowie 1992; Smith 1995) with high humidity and reduced air movement that might otherwise promote excessive water loss. Crampton (1925) described the habitat requirements of the partulid trees snails of the Mariana Islands as having sufficiently high and dense growth to provide shade, to conserve moisture, and to effect the production of a rich humus. Hence the limits to the areas occupied by Partulae are set by the more ultimate ecological conditions which determine the distribution of suitable vegetation. Crampton (1925) further describes the intact structure of native Mariana forests as having four general levels: the high trees; the shrubs and Pandanus spp.; the cycads and taller ferns; and the succulent herbs. He notes that the Mariana Islands partulid tree snails preferentially live on subcanopy vegetation and do not use the high canopy trees. The habitat requirements for the humped tree snail include coastal strand vegetation, forested river borders, and lowland and highland forests (Crampton 1925). According to recent, unpublished survey data, Sischo (in litt. 2011) found that individuals of the humped tree snail resided in fragmented patches of native habitat and that the habitat was drier than habitat in which the species was frequently found.

Dispersal/Migration

Motility/Mobility

Adult: low

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory

Dispersal

Adult: low

Immigration/Emigration

Adult: unlikely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Adult: not applicable

Dispersal/Migration Narrative

Adult: There is not a lot of information regarding the dispersal of this species

Population Information and Trends

Population Trends:

Declining or extirpated, except for possibly the Sarigan population

Species Trends:

Declining

Resiliency:

low

Representation:

low

Redundancy:

low

Population Growth Rate:

unknown

Number of Populations:

13 to 16

Population Size:

less than 2600

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

This species is considered to be rare throughout most of its range (Hopper and Smith 1992). The best estimate for the total number of remaining snails is less than 2,600. Details follow regarding the species in various parts of its range.

Threats and Stressors

Stressor: Habitat loss and degradation
Exposure:
Response:
Consequence:
Narrative: The humped tree snail prefers cool, shaded forest habitats (Crampton 1925; Cowie 1992; Smith 1995) with high humidity and reduced air movement that might otherwise promote excessive water loss. These forest habitats include coastal strand forest, forested river borders, and both lowland and highland native forests (Crampton 1925). Currently, fragmented habitat for this species can still be found within its range in the Mariana Islands. However, it has severely declined or has been degraded due to extensive forest clearing for agriculture and development, introduced weed species, and introduced feral ungulates over the last century. Following World War II, open agricultural fields and other areas prone to erosion were seeded with Leucaena leucocephala (tangantangan), small trees which grow as single species stands with no substantial understory. The micro-climate in these areas now occupied by L. leucocephala is dry, with little accumulation of leaf litter humus, and is particularly unsuitable as partulid tree snail habitat (Hopper and Smith 1992). In addition, native forest cannot reestablish and grow where this alien weed has become established (Hopper and Smith 1992).

Stressor: Feral ungulates
Exposure:
Response:
Consequence:
Narrative: Throughout the Mariana Islands, feral ungulates, including pigs (Sus scrofa), Philippine deer (Cervus mariannus), cattle (Bos taurus), water buffalo (Bubalus bubalis), and goats (Capra hircus), have caused severe damage to native forest vegetation by browsing directly on plants, causing erosion (Marshall et al. 1995, Kessler 1997, Sischo, in litt. 2011), and retarding forest growth and regeneration (Lemke 1992). This in turn reduces the quantity and quality of forested habitat for the humped tree snail. Currently, populations of feral ungulates are found on the islands of Guam (deer, pigs, and water buffalo), Rota (deer and cattle), Aguiguan (goats), Tinian (cattle), Saipan (deer, pigs, and cattle), Anatahan (pigs and goats), Alamagan (goats, pigs, and cattle), and Pagan (cattle, goats, and pigs). Goats were eradicated from Sarigan in 1998 (Zoology Unlimited LLC 1998) and the humped tree snail has increased in abundance, perhaps in response to their removal.

Stressor: Military activity
Exposure:
Response:
Consequence:
Narrative: The proposed expansion of U.S. military facilities, troops, and maneuvers on Guam, and the proposed expansion of the same, including live ordinance (e.g., bomb and artillery)

testing on Pagan, pose a potential serious threat to the native habitat of the humped tree snail on Guam and Pagan (Sischo, in litt. 2011).

Stressor: Natural events
Exposure:
Response:
Consequence:
Narrative: In addition to human-related habitat alteration, natural events such as typhoons and volcanic activity have also impacted the humped tree snail habitat. The island of Anatahan experienced volcanic eruptions beginning in 2003 and continuing into early 2005. Much of the land area was buried by a thick ash layer. These eruptions removed an estimated 95 percent of all vegetation and the effect on the snails is unknown but presumed to be negative (USFWS and CNMI 2006). Pagan has also experienced volcanic activity as recently as 1993. Typhoons are a common occurrence in the Mariana Islands. Guam, for example, has been affected by typhoons in 37 of the 50 years between 1954 and 2004 (Naval Pacific Meterology and Oceanography Center Joint Typhoon Warning Center (JTWC) 2007). During the 1990s, Guam experienced 20 typhoons, and super-typhoons (having gusts exceeding 150 miles per hour (mph) (240 kilometers per hour (kph))) occur with regularity (about once every 5 to 10 years). There is some evidence that the frequency of severe storms (estimated gusts exceeding 100 mph (160 kph)) is increasing in the Mariana Islands. With reference to Guam, the historical record shows increasing numbers of mild (estimated gusts in the range of 50 to 100 mph (80 to 160 kph)) and severe storms over the last three centuries, as well as in just the last decade (JTWC 2007). These storms have been known to defoliate forested areas and down trees, which can impact tree snail populations. For example, in August 2004, Typhoon Chaba stalled 25 mi (40 km) north of Rota for several hours, downing trees and defoliating large sections of the forested areas, especially on the windward side of the island (JTWC 2007). Vegetation changes associated with this storm have opened up forested areas that were excellent habitat for partulid tree snails. These open forests suffer from changes in microhabitat, such as desiccation, that make the continued survival of snails unlikely. These changes continue to occur today with each successive typhoon (Amidon 2005, pers. comm.).

Stressor: Collection
Exposure:
Response:
Consequence:
Narrative: Tree snails can be found around the world in tropical and subtropical regions and have been valued as collectibles for centuries. Evidence of tree snail trading among prehistoric Polynesians was discovered by a genetic characterization of the enigmatic multi-archipelagic distribution of Partula hyalina, a tree snail endemic to Tahiti, and related taxa (Lee et al. 2007). In their study, Lee et al. (2007) found evidence that this Tahitian tree snail had been traded as far away as Mangaia in the Southern Cook Islands, a distance of over 500 mi (805 km). Based on the history of collection of endemic Pacific Island tree snails, the market for tropical tree snail shells and the vulnerability of the small populations of humped tree snail to the negative impacts of any collection, we consider the potential over-collection of Partula spp. tree snails to pose a potentially serious threat because it can occur at any time, although its occurrence is not predictable.

Stressor: Predation by Invasive species

Exposure:
Response:
Consequence:
Narrative: Predation by the alien rosy carnivore snail (Euglandina rosea) and the alien Manokwar flatworm (Platydemus manokwari) are serious and ongoing threats to the survival of all four species of partulid tree snails from the Mariana Islands. The predatory rosy carnivore snail is native to the southeastern United States and was introduced into the Mariana Islands in 1957 (Eldredge 1988). Since being introduced, this voracious predator of snails has been dispersed by humans throughout the main islands. The rosy carnivore snail was imported to these and other Pacific islands as a biological control agent for another alien snail, the giant African snail (Achatina fulica), which is an agricultural pest. Field observations have established that the rosy carnivore snail readily feeds on native Pacific island tree snails, including the partulids of the Mariana Islands (Tillier and Clarke 1983; Murray et al. 1988; Miller 1993) and the Hawaiian achatinellid tree snails (Hadfield et al. 1993). A study of the diet of the rosy carnivore snail on the island of Mauritius in the Indian Ocean showed that this alien predator preferred native snails over the targeted alien giant African snail (Griffiths et al. 1993). On some or all of these tropical islands, the rosy carnivore snail has expanded its normal terrestrial feeding behavior to include native snails found in arboreal habitats (Murray et al. 1988; Hadfield et al. 1993; Miller 1993). It has caused the extinction of many populations and species of native snails throughout the Pacific islands (Tillier and Clarke 1983; Murray et al. 1988; Hopper and Smith 1992; Hadfield et al. 1993; Miller 1993). The rosy carnivore snail represents a significant threat to the survival of native Mariana Islands snails, including the humped tree snail. Predation on native partulid tree snails by the terrestrial Manokwar flatworm is also a threat to their long-term survival. This voracious snail predator was introduced into Guam in 1978 and has been spread by humans throughout the main Mariana Islands (Eldredge 1988). It has proven to be an effective biological control agent for the giant African snail, but has also contributed to the decline of native tree snails, in part due to its ability to ascend into trees and bushes that support native snails. Areas with populations of the flatworm usually lack partulid tree snails or have declining numbers of snails (Hopper and Smith 1992). It is suggested that rats (Rattus spp.) are likely responsible for the greatest number of animal extinctions on the islands, including extinctions of snail species (Towns et al. 2006). In the Hawaiian Islands, rats are known to prey upon endemic arboreal snails and are a serious and ongoing threat to the long-term survival of all endemic tree snails (Hadfield et al. 1993, p. 621). In the Mariana Islands, predation by rats is a threat to the long-term survival of partulid tree snails because they have been observed consuming other Partula spp., and rats and humped tree snails occur on the same islands (Sischo, in litt. 2011).

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The humped tree snail currently receives protection under the Guam Endangered Species Act (5GCA § 63205(c)).

Stressor: Isolated/fragmented populations
Exposure:
Response:
Consequence:

Narrative: Even if the threats responsible for the decline of this species were controlled, the persistence of existing populations is hampered by the small number of extant populations and the small geographic range of the known populations. These circumstances make the species more vulnerable to extinction due to a variety of natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Pimm et al. 1988; Center for Conservation Biology 1994; Mangel and Tier 1994). Randomly occurring natural events such as typhoons and droughts could eliminate one or more of the 14 remaining populations of the humped tree snail. This is especially true due to several life-history features of this and all other partulid tree snails (Cowie 1992): reproductive rates are low; eggs are not laid as in most terrestrial snails but young are born live; and dispersal is very limited with most individuals remaining in the tree or bush into which they were born. All of these traits make these snails very sensitive to any random event that could lead to a reduction or loss of reproductive individuals.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- A project to survey endemic land snails has been funded under the State Wildlife Grant. Snail surveys will be conducted on Tinian, Rota, Saipan, and Asuncion (Igisomar, in litt. 2008).
- Conduct long-term monitoring surveys for the humped tree snail
- Develop and implement nonnative flatworm removal and control program
- Develop and implement nonnative snail removal and control program
- Conduct feral ungulate removal and control program
- Conduct habitat restoration program and remove nonnative plant species

Conservation Measures and Best Management Practices:
- In 1998, feral goats were successfully removed from the small volcanic island of Sarigan.

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2013

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM
06/01/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM
06/01/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM
06/01/2018

SPECIES ACCOUNT: *Partula langfordi* (Langford's tree snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2015; Pacific Region (R1) (USFWS, 2016)

Physical Description

Langfords tree snail (Partula langfordi) has a dextral shell described by Kondo (1970) as being ovate-conic and moderately thin. It has a spire of five whorls that are slightly convex, with an obtuse apex. Its aperture is oblong-ovate with the white peristome thickened and expanded. Its background is buff colored superimposed by maroon. A band on whorls two and three is also maroon. The band begins at whorl one and a half as a faint brown marking one-third the width of the whorl and gradually widens to one-half width of the whorl and deepens to maroon at whorl three. The band expands to three-fourths width of whorl four and dissipates into a vague blend of buff-maroon at the beginning of whorl five to the end of the shell. The holotype of this species has a length of 0.55 inch (in) (14.0 millimeters (mm)), a diameter of 0.35 in (9 mm), and a aperture length of 0.31 in (8 mm) (Kondo 1970).

Taxonomy

The genus Partula has four species found only in the Mariana Islands and 94 additional species recorded from other Pacific islands (Cowie 1992). Langfords tree snail was first collected and described by Kondo while working on biological control agents in the early 1950s (Kondo 1970). Kondos 1970 taxonomic work is the most recent and accepted taxonomy for this species.

Historical Range

The three genera and 126 tree snail species of the family Partulidae are restricted to the high islands (not atolls) of the Pacific, excluding the Hawaiian Islands (Kondo 1970, Cowie 1992, and Paulay 1994). The Mariana archipelago historically supported five species of partulid tree snails, and represents the northwestern limit of the geographical range of the Partulidae (Kondo 1970). The Langfords tree snail is only known from the small island of Aguiguan where it occurs sympatrically with the humped tree snail (Partula gibba) (Kondo 1970).

Current Range

The Langfords tree snail is only known from the island of Aguiguan in the CNMI (Cowie 1992). During a survey conducted in November 2006, no live Langfords tree snails were found (Igisomar, in litt. 2008).

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

<u>Adult:</u> The snails are generally nocturnal, living on bushes or trees and feeding primarily on senescent or decaying plant material.

Reproduction Narrative

Adult: The biology of the partulid tree snails of the Mariana Islands has not been studied in detail. However, general information on the biology of closely related partulid tree snails has been published and reviewed by Cowie (1992) and the biology of all these species is very similar. As with all terrestrial pulmonate snails, the Mariana Islands tree snails are hermaphroditic. In general, partulid snails begin reproducing in less than 12 months and may live up to 5 years. Up to 18 young are produced each year and some species may be self-fertile. While most terrestrial snails lay eggs, the partulid tree snails give birth to live young.

Spatial Arrangements of the Population

Adult: Clumped according to suitable habitat

Tolerance Ranges/Thresholds

Adult: Unknown

Site Fidelity

Adult: Likely high

Habitat Narrative

Adult: The Langfords tree snail prefers cool, shaded forest habitats (Smith 1995) with high humidity and reduced air movement that might otherwise promote excessive water loss. Crampton (1925) described the habitat requirements of the partulid tree snails of the Mariana Islands as having sufficiently high and dense growth to provide shade, to conserve moisture, and to effect the production of a rich humus. Hence the limits to the areas occupied by Partulae are set by the more ultimate ecological conditions which determine the distribution of suitable vegetation. Crampton (1925) further described the intact structure of native Mariana forests as having four general levels: high trees; shrubs and Pandanus spp.; cycads and taller ferns; andsucculent herbs. He noted that the Mariana Islands partulid tree snails preferentially live on subcanopy vegetation and do not use the high canopy trees (Crampton 1925). In 1994, the International Union for Conservation of Nature and Natural Resources the World Conservation Unions Species Survival Committee Mollusc Specialist Group, Captive Breeding Specialist Group and Pacific Island Land Snail Group held a three day symposium to draft an Action Plan for the Conservation of the Family Partulidae. They determined that the potential range by ecographic zonation for Langfords tree snail was less than four square miles (ten square kilometers). They were unable to estimate the area that was considered occupied by the snail (Pearce-Kelly et al. 1994).

Dispersal/Migration

Motility/Mobility

Adult: presumablly low

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory

Dispersal

Adult: presumablly low

Immigration/Emigration

Adult: Not likely because of fragmented habitat

Dispersal/Migration Narrative

Adult: Little information exists regarding the dispersal of this species.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Resiliency:

low

Representation:

low

Redundancy:

low

Population Growth Rate:

unknown

Number of Populations:

0 to 1

Population Size:

Unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

In 1970, the Langfords tree snail was collected from an area where it occurred sympatrically with the humped tree snail (Kondo 1970). The mixed populations were not uniformly distributed, but occurred in small colonies with large unoccupied areas between the colonies. In five of the sites, the Langfords tree snail outnumbered the humped tree snail and it appeared that humped tree snails were more numerous and dominant in the western portion of the site while Langfords tree snails were dominant in the eastern portion of the site (Kondo 1970). Three other colonies of Langfords tree snail were collected, two on the north coast and one on the west end of Aguiguan (Kondo 1970). A total of 464 adults were collected from seven sites(Kondo 1970). In 1985, five adult Langfords tree snails were collected from the west end of the island (Smith 1995). The last survey, in which the species was detected in the wild, was done in 1992, and one live snail was observed on the northwest terrace of the island (Smith 1995). A survey of Aguiguan in November 2006 failed to find any live Langfords tree snails. In 1993, Nottingham University had six young and four adult Langfords tree snail in captivity. In 1994, they had a total of two adults. Unfortunately, at the end of 1994, Nottingham Universitys last two Langfords tree snails died (Pearce-Kelly et al. 1995).

Threats and Stressors

Stressor: Habitat loss and degradation
Exposure:
Response:
Consequence:
Narrative: In the 1930s, the island of Aguiguan was mostly cleared of native forest to support sugar cane and pineapple production. The abandoned fields and airstrip are now over grown with alien weeds. The remaining native forest understory has greatly suffered from large and uncontrolled populations of alien goats (Capra hircus) and the invasion of weeds (Engbring et al. 1986).

Stressor: Feral ungulates
Exposure:
Response:
Consequence:
Narrative: Cruz et al. (2003), observed a forest limited in native species with a bare understory and low seedling recruitment due to browsing by feral goats.

Stressor: Invasive vegetation
Exposure:
Response:
Consequence:
Narrative: The most disturbed areas are now dominated by Lantana camara (West Indian lantana), which is invading the upper reaches of the island and in open field regions leaving no room for native species recruitment (Cruz et al. 2003).

Stressor: Natural events
Exposure:
Response:
Consequence:
Narrative: Typhoons are a common occurrence in the Mariana Islands. Guam, for example, has been affected by typhoons in 37 of the 50 years between 1954 and 2004 (Naval Pacific Meterology and Oceanography Center Joint Typhoon Warning Center (JTWC) 2007). During the 1990s Guam experienced 20 typhoons, and super-typhoons (having gusts exceeding 150 miles per hour (mph) (240 kilometers per hour (kph))) occur with regularity (about once every 5 to 10 years). There is some evidence that the frequency of severe storms (estimated gusts exceeding

100 mph (160 kph)) is increasing in the Mariana Islands. These storms have been known to defoliate forested areas and down trees, which can impact tree snail populations. For example, in August 2004, Typhoon Chaba stalled 25 miles (mi) (40 kilometers (km)) north of Rota for several hours, downing trees and defoliating large sections of the forested areas, especially on the windward side of the island (JTWC 2007). Vegetation changes associated with this storm have opened up forested areas that were excellent habitat for partulid tree snails. These open forests suffer from changes in microhabitat, such as desiccation, that make the continued survival of snails unlikely. These changes continue to occur today with each successive typhoon (Amidon 2005, pers. comm.).

Stressor: Collection
Exposure:
Response:
Consequence:
Narrative: Tree snails can be found around the world in tropical and subtropical regions and have been valued as collectibles for centuries. Evidence of tree snail trading among prehistoric Polynesians was discovered by a genetic characterization of the enigmatic multi-archipelagic distribution of Partula hyalina, a tree snail endemic to Tahiti, and related taxa (Lee et al. 2007). In their study, Lee et al. (2007) found evidence that this Tahitian tree snail had been traded as far away as Mangaia in the Southern Cook Islands, a distance of over 500 mi (805 km). Based on the history of collection of endemic Pacific Island tree snails, the market for tropical tree snail shells, and the vulnerability of the small number of Langfords tree snail to the negative impacts of any collection, we consider the potential overcollection of Partula tree snails to pose a potentially serious threat, because it can occur at any time, although its occurrence is not predictable.

Stressor: Invasive animals
Exposure:
Response:
Consequence:
Narrative: Predation by the alien rosy carnivore snail (Euglandina rosea) and the alien Manokwar flatworm (Platydemus manokwari) is a serious threat to the survival of all four species of partulid tree snails from the Mariana Islands. The predatory rosy carnivore snail is native to the southeastern United States, and was introduced into the Mariana Islands in 1957 by the governments of Guam and the Commonwealth of the Northern Mariana Islands as a biocontrol agent (Eldredge 1988). The rosy carnivore snail readily feeds on native Pacific island tree snails, including the partulids (Tillier and Clarke 1983; Murray et al. 1988; Miller 1993) and the Hawaiian achatinellid tree snails (Hadfield et al. 1993). A study of the diet of the rosy carnivore snail on the island of Mauritius in the Indian Ocean showed that this alien predator preferred native snails over the targeted alien giant African snail (Achatina fulica) (Griffiths et al. 1993). The rosy carnivore snail represents a significant threat to the survival of native Mariana Islands snails, including Langfords tree snail. Predation on native partulid tree snails by the terrestrial Manokwar flatworm is also a threat to their long-term survival. This voracious snail predator was introduced into Guam in 1978 and has been spread by humans throughout the main Mariana Islands (Eldredge 1988). The Manokwar flatworm has also contributed to the decline of native tree snails, in part due to its ability to ascend into trees and bushes that support native snails. Areas with populations of the flatworm usually lack partulid tree snails or have declining numbers of snails (Hopper and Smith 1992). In 1992 a survey was conducted during which one Langfords tree snail was observed on the leaves of a Guamia mariannae (Pai-Pai) plant about 9

feet (3 meters) above the ground. The shells of dead Langfords tree snails and humped tree snails littered the ground (Smith 1995). In addition, a dense aggregation of the Manokwar flatworm was also found in the same area (Smith 1995). It is suggested that rats (Rattus spp.) are likely responsible for the greatest number of animal extinctions on islands, including extinctions of snail species (Towns et al. 2006, p. 88). In the Hawaiian Islands, rats are known to prey upon endemic arboreal snails and are a serious and ongoing threat to the long-term survival of all endemic tree snails (Hadfield et al. 1993, p. 621). In the Mariana Islands, predation by rats is a threat to the long-term survival of partulid tree snails because they have been observed consuming other Partula spp. and rats occur on Aguiguan (Adams et al. 2010; Sischo, in litt. 2011).

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: Currently, no formal or informal protection is given to the Langfords tree snail.

Stressor: Isolated/fragmented populations
Exposure:
Response:
Consequence:
Narrative: Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Pimm et al. 1988; Center for Conservation Biology 1994; Mangel and Tier 1994). Randomly occurring natural events such as typhoons and droughts could eliminate the only known population of Landfords tree snail. This is especially true due to several life-history features of this and all other partulid tree snails (Cowie 1992). Reproductive rates are lower than most terrestrial snails as tree snails do not lay large numbers of eggs but bear one to two live young, which means lower numbers of individuals are added to the population and dispersal is very limited with most individuals remaining in the tree or bush into which they were born. All of these traits make these snails very sensitive to any randomly occurring natural events such as typhoons and storms that could lead to a reduction or loss of reproductive individuals.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- Conduct extensive surveys for Langfords tree snails
- Develop and implement nonnative snail removal and control program
- Develop and implement nonnative flatworm removal and control program
- Develop and implement feral goat removal and control program
- Develop and implement habitat restoration program and remove nonnative plant species

- Expand and reinvigorate captive propagation program

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2013

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U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2019

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2020

SPECIES ACCOUNT: *Partula radiolata* (Guam tree snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2015; Pacific Region (R1) (USFWS, 2016)

Physical Description

The shell of the Guam tree snail (Partula radiolata) was described by Pilsbry (1909-1910) as subperforate, oblong-tapering, the apex obtuse, thin; sculptured with distant impressed spiral lines; pale straw-colored, rayed with darker streaks and brown lines. Whorls 5, slightly convex, the last about equal to the spire, base tumid in front. The species columella is short, usually shortly receding. The species aperture is obliquely oval, glossy inside, and yellow; the peristome is simple, thin, white, expanded, the right margin somewhat straightened, columellar margin dilated above, and spreading above the umbilicus. The species length is approximately 19 millimeters (mm) (0.75 inches (in)), with a diameter of 10 mm (0.39 in), and an aperture ranging from 9 to 5 mm (0.35 to 0.20 in) inside.

Taxonomy

The family Partulidae has three genera and 123 tree snail species and is restricted to the Pacific Islands. The genus Partula has four species found only in the Mariana Islands, and 94 additional species recorded from other Pacific islands. The Guam tree snail was first collected by Quoy and Gaimard during the French Astrolabe expedition of 1828 (Crampton 1925). Cramptons 1925 taxonomic work is the most recent and accepted taxonomy for this species.

Historical Range

The tree snail species of the family Partulidae are restricted to the high-elevation Pacific islands (Cowie 1992; Paulay 1994). The Mariana archipelago historically supported five species of partulid tree snails, and represents the northwestern limit of the geographical range of the Partulidae. The Guam tree snail is restricted to the island of Guam.

Current Range

The Guam tree snail occurs only on the island of Guam.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: The snails are generally nocturnal, living on bushes or trees and feeding primarily on senescent or decaying plant material.

Reproduction Narrative

Adult: The biology of the partulid tree snails of the Mariana Islands has not been studied in detail. However, general information on the biology of closely related partulid tree snails has been published and reviewed by Cowie (1992) and the biology of all of these species is very similar. As with all terrestrial pulmonate (having lungs or lung-like organs) snails, the Mariana Islands tree snails are hermaphroditic. In general, partulid snails begin reproducing in less than 12 months and may live up to 5 years. Up to 18 young are produced each year and some species may be self-fertile. While most terrestrial snails lay eggs, the partulid tree snails give birth to live young.

Spatial Arrangements of the Population

Adult: clumped according to suitable habitat

Tolerance Ranges/Thresholds

Adult: unknown

Habitat Narrative

Adult: The Guam tree snail prefers cool, shaded forest habitats (Crampton 1925; Cowie 1992; Smith 1995) with high humidity and reduced air movement that might otherwise promote excessive water loss. Crampton (1925) described the habitat requirements of the partulid tree snails of the Mariana Islands as having sufficiently high and dense growth to provide shade, to conserve moisture, and to effect the production of a rich humus. Hence the limits to the areas occupied by Partulae are set by the more ultimate ecological conditions which determine the distribution of suitable vegetation. Crampton (1925) further described the intact structure of native Mariana forests as having four general levels: high trees; shrubs and Pandanus spp.; cycads and taller ferns; and succulent herbs. He noted that the Mariana Islands partulid tree snails preferentially live on subcanopy vegetation and do not use the high canopy trees. Suitable habitat for the Guam tree snail was widely available on Guam prior to World War II and included coastal strand vegetation, forested river borders, and lowland and highland forests (Crampton 1925).

Dispersal/Migration

Motility/Mobility

Adult: low

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory

Dispersal

Adult: low

Immigration/Emigration

Adult: unlikely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Adult: not applicable

Dispersal/Migration Narrative

Adult: There is not a lot of information regarding the dispersal of this species

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Resiliency:

low

Representation:

low

Redundancy:

low

Population Growth Rate:

unknown

Number of Populations:

22

Population Size:

Unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Currently, there are 22 known populations of the Guam tree snail. Crampton (1925) found the Guam tree snail at 37 of 39 sites surveyed on Guam and collected between 2 to 312 snails from each site. A total of 2,278 individuals were collected. The actual population sizes were probably considerably larger since the purpose of Cramptons collections was to evaluate geographic differences in shell patterns and not to assess population size. Since the work of Crampton (1925), no significant evaluation of the Guam tree snail occurred until the 1980s and 1990s. In 1989, Hopper and Smith (1992) resurveyed 34 of Crampton's 39 sites on Guam plus 13 new sites. Nine of the 34 sites resurveyed by Hopper and Smith (1992) still supported these snails in 1989. The Crampton site identified as having the largest remaining population of the Guam tree snail (estimated at greater than 500 snails) in 1989 has been completely eliminated by the combined effects of land clearing for a residential development and a subsequent series of typhoons in 1990, 1991, and 1992 (Smith 1995). Hopper and Smith (1992) considered this species to be rare throughout its range and estimated that the number of sites that support the Guam tree snail have decreased by 74 percent since Cramptons work in 1920.

Threats and Stressors

Stressor: Habitat loss and degradation
Exposure:
Response:
Consequence:
Narrative: Following World War II, open agricultural fields and other areas prone to erosion were seeded with Leucaena leucocephala (tangantangan), small trees which grow as single species stands with no substantial understory. The microclimatic condition in such areas is dry with little accumulation of leaf litter humus and is particularly unsuitable as partulid tree snail habitat (Hopper and Smith 1992). Native forest species cannot reinvade and grow where this alien weed has become established (Hopper and Smith 1992).

Stressor: Natural Events
Exposure:
Response:
Consequence:
Narrative: Typhoons are a common occurrence on Guam and have impacted the remaining forest on the island. The island of Guam has been affected by typhoons in 37 of the 50 years between 1954 and 2004 (Naval Pacific Meterology and Oceanography Center Joint Typhoon Warning Center (JTWC) 2007). During the 1990s Guam experienced 20 typhoons, and super-typhoons (having gusts exceeding 150 miles per hour (mph) (240 kilometers per hour (kph))) occur with regularity (about once every 5 to 10 years). The historical record for Guam shows increasing numbers of mild (estimated gusts in the range of 50 to 100 mph (80 to 160 kph)) and severe storms over the last three centuries, as well as in just the last decade (JTWC 2007). Vegetation changes associated with these storms have opened up forested areas that were excellent habitat for partulid tree snails. These open forests suffer from changes in microhabitat, such as desiccation, that make the continued survival of snails unlikely. These changes continue to occur today with each successive typhoon (Amidon 2005, pers. comm.).

Stressor: Feral ungulates
Exposure:
Response:
Consequence:
Narrative: The structure of the limestone forest on Guam is slowly changing due to the presence of Philippine deer (Cervus marianuns), feral pigs (Sus scrofra), and water buffalo (Bubalus bubalis), as they browse on seeds and seedlings retarding regeneration of the forest plants (Wiles et al. 1999). These ungulates have caused severe damage to native forest vegetation by browsing directly on plants, causing erosion (Marshall et al. 1995; Kessler 1997) and retarding forest growth and regeneration (Lemke 1992). This in turn reduces the quantity and quality of forested habitat for the Guam tree snail.

Stressor: Military activity
Exposure:
Response:

Consequence:
Narrative: The proposed expansion of U.S. military facilities, troops, and maneuvers on Guam poses a potential serious threat to the native habitat of the Guam tree snail.

Stressor: Collection
Exposure:
Response:
Consequence:
Narrative: Tree snails can be found around the world in tropical and subtropical regions and have been valued as collectibles for centuries. Evidence of tree snail trading among prehistoric Polynesians was discovered by a genetic characterization of the enigmatic multi-archipelagic distribution of Partula hyalina, a tree snail endemic to Tahiti, and related taxa (Lee et al. 2007). In their study, Lee et al. (2007) found evidence that this Tahitian tree snail had been traded as far away as Mangaia in the Southern Cook Islands, a distance of over 500 miles (805 kilometers). Based on the history of collection of endemic Pacific Island tree snails, the market for tropical tree snail shells, and the vulnerability of the small populations of the Guam tree snail to the negative impacts of any collection, we consider the potential overcollection of Partula tree snails to pose a potentially serious threat because it can occur at any time, although its occurrence is not predictable.

Stressor: Invasive predators
Exposure:
Response:
Consequence:
Narrative: Predation by the alien rosy carnivore snail (Euglandina rosea) and the alien Manokwar flatworm (Platydemis manokwari) is a serious threat to the survival of all four species of partulid tree snails from the Mariana Islands. The predatory rosy carnivore snail is native to the southeastern United States, and was introduced into the Mariana Islands and Guam in 1957 (Eldredge 1988). Since being introduced, this voracious predator of snails has been dispersed by humans throughout the main islands. The rosy carnivore snail was imported to these and other Pacific islands as a biological control agent for another alien snail, the giant African snail (Achatina fulica), which is an agricultural pest. However, while its effectiveness as a biological control agent against the giant African snail is questionable (Mead 1961; Tillier and Clarke 1983; Christiansen 1984), field observations have established that the rosy carnivore snail will readily feed on native Pacific island tree snails, including the Partulidae (Tillier and Clarke 1983; Murray et al. 1988; Miller 1993) and the Hawaiian achatinellid tree snails (Hadfield et al. 1993). A study of the diet of the rosy carnivore snail on the island of Mauritius in the Indian Ocean showed that this alien predator preferred native snails over the targeted alien giant African snail (Griffiths et al. 1993). On some or all of these tropical islands, the rosy carnivore snail has expanded its normal terrestrial feeding behavior to include native snails found in arboreal habitats (Murray et al. 1988; Hadfield et al. 1993; Miller 1993). The rosy carnivore snail has caused the extinction of many populations and species of native snails throughout the Pacific islands (Tillier and Clarke 1983; Murray et al. 1988; Hopper and Smith 1992; Hadfield et al. 1993; Miller 1993). Predation on native partulid tree snails by the terrestrial Manokwar flatworm is also a threat to the long-term survival of these snails. This voracious snail predator was introduced into Guam in 1978 and has been spread by humans throughout the main Mariana Islands (Eldredge 1988). The Manokwar flatworm has also contributed to the decline of native tree snails, in part due to its ability to ascend into trees and bushes that support native snails. Areas with populations of the

flatworm usually lack partulid tree snails or have declining numbers of snails (Hopper and Smith 1992). It is suggested that rats (Rattus spp.) are likely responsible for the greatest number of animal extinctions on islands, including extinctions of snail species (Towns et al. 2006, p. 88). In the Hawaiian Islands, rats are known to prey upon endemic arboreal snails and are a serious and ongoing threat to the long-term survival of all endemic tree snails (Hadfield et al. 1993, p. 621). In the Mariana Islands, predation by rats is a threat to the long-term survival of partulid tree snails because they have been observed consuming other Partula spp. and rats occur on Guam (Sischo, in litt. 2011).

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The Guam tree snail currently receives protection under the Guam Endangered Species Act (5GCA § 63205(c)).

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- Conduct surveys for Guam tree snails
- Develop and implement nonnative snail removal and control program
- Develop and implement nonnative flatworm removal and control program
- Conduct habitat restoration remove nonnative plant species
- Conduct ungulate (deer, pigs, and water buffalo) removal and control

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2013

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM
06/01/2018

SPECIES ACCOUNT: *Partulina semicarinata* (Lanai tree snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 06/27/2013; Pacific Region (R1) (USFWS, 2016)

Physical Description

The shell may coil to the right (dextral) or left (sinistral), but appears to be constant within a population. The oblong to ovate shells of the adult are 0.6 to 0.8 in (16 to 20 mm) long, have 5 to 7 whorls, and range in color from rusty brown to white, with some individuals having bands around the shells. The shell has a distinctive keel that runs along the last whorl, and is more distinctive in juveniles (Pilsbry and Cooke 1912–1914, pp. 86–88) (USFWS, 2012).

Taxonomy

Partulina semicarinata (Lanai tree snail, pupu kani oe), a member of the family Achatinellidae and the endemic Hawaiian subfamily Achatinellinae, is known only from the island of Lanai (Pilsbry and Cooke 1912–1914, p. 86).

Historical Range

See current range/distribution

Current Range

Historic populations of Partulina semicarinata were restricted to the wet and mesic ohia forests on the island of Lanai. Endemic to the remaining wet forests on the Hawaiian island of Lanai. This species was originally described from Ranai [Lanai], Hawaiian Islands (Johnson, 1996).

Critical Habitat Designated

Yes; 3/30/2016.

Legal Description

On March 30, 2016, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Partulina semicarinata (Lanai tree snail) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes an unknown number of critical habitat units (CHUs), in Hawaii (81 FR 17790-18110).

Critical Habitat Designation

The critical habitat designation for Partulina semicarinata includes an unknown number of CHUs in Maui County, Hawaii. The number of CHUs is unknown because detailed CHU information is not available fot the island of Lanai (81 FR 17790-18110).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Partulina semicarinata critical habitat consists of three components. Lowland wet (Lanai), Montane wet (Lanai) and Wet cliff (Lanai) (81 FR 17790-18110):

Ecosystem: Lowland Wet. Elevation: <3,330 ft (<1,000 m). Annual precipitation: 50–75 in (130–190 cm). Substrate: Clays; ashbeds; deep, well drained soils; lowland bogs. Canopy: Antidesma, Metrosideros, Myrsine, Pisonia, Psychotria. Subcanopy: Cibotium, Claoxylon, Kadua, Melicope. Understory: Alyxia, Cyrtandra, Dicranopteris, Diplazium, Machaerina, Microlepia.

Ecosystem: Montane Wet. Elevation: 3,300–6,500 ft (1,000–2,000 m). Annual precipitation: >75 in (>190 cm). Substrate: Well-developed soils, montane bogs. Canopy: Acacia, Charpentiera, Cheirodendron, Metrosideros. Subcanopy: Broussaisia, Cibotium, Eurya, Ilex, Myrsine. Understory: Ferns, Carex, Coprosma, Leptecophylla, Oreobolus, Rhynchospora, Vaccinium.

Ecosystem: Wet Cliff. Elevation: unrestricted. Annual precipitation: >75 in (>190 cm). Substrate: >65 degree slope, shallow soils, weathered lava. Canopy: None. Subcanopy: Broussaisia, Cheirodendron, Leptecophylla, Metrosideros. Understory: Bryophytes, Ferns, Coprosma, Dubautia, Kadua, Peperomia.

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 that are essential to the conservation of the species and which may require special management considerations or protection. In identifying critical habitat in occupied areas, we determine whether those areas that contain the features essential to the conservation of the species require any special management actions. Although the determination that special management may be required is not a prerequisite to designating critical habitat in unoccupied areas, special management is needed throughout all of the critical habitat units in this final rule. The following discussion of special management needs is therefore applicable to each of the Maui Nui species for which we are designating critical habitat in this rule. In this final rule, we are designating critical habitat for 125 of the 135 species for which we proposed critical habitat. For the reasons described below (see Exclusions Based on Other Relevant Factors), we are not designating critical habitat for eight plants (Abutilon eremitopetalum, Cyanea gibsonii, Kadua cordata ssp. remyi, Labordia tinifolia var. lanaiensis, Pleomele fernaldii, Portulaca sclerocarpa, Tetramolopium lepidotum ssp. lepidotum, and Viola lanaiensis) and two tree snails (Partulina semicarinata and P. variabilis). The 125 species for which we are designating critical habitat include 108 plant and animal species that are currently found in the wild on Molokai, Maui, and Kahoolawe; (10 plant species which were historically found on one or more of these islands, but are currently found only on other Hawaiian Islands (Adenophorus periens, Clermontia peleana, Cyanea grimesiana ssp. grimesiana, Cyperus trachysanthos, Eugenia koolauensis, Gouania vitifolia, Isodendrion pyrifolium, Kadua coriacea, Nototrichium humile, and Solanum incompletum), 6 plant species that may not be currently extant in the wild (Acaena exigua, Cyanea glabra, Phyllostegia bracteata, P. haliakalae, Schiedea jacobii, and Tetramolopium capillare), and 1 plant species, Kokia cookei, which exists only in cultivation. For each of the 108 species currently found in the wild on Molokai, Maui, and Kahoolawe, we have determined that the features essential to their conservation are those required for the successful functioning of the ecosystem(s) in which they occur (see Tables 5 and 6, above). As described earlier, in some cases, additional species-specific primary constituent elements were also identified (see Table 6, above). Special management considerations or protections are necessary throughout the critical habitat areas designated here to avoid further degradation or destruction of the habitat that provides those features essential to their conservation. The primary threats to the physical or biological features essential to the conservation of all of these species include habitat destruction and modification by nonnative ungulates, competition with nonnative species, hurricanes, landslides, rockfalls, flooding, fire, drought, and climate change. Additionally, the rosy wolf snail poses a threat to the Newcomb's tree snail and mosquito-borne diseases pose threats to the two forest birds. The reduction of these threats will require the implementation of special management actions within each of the critical habitat areas identified in this final rule. All designated critical habitat requires active management to address the ongoing degradation and loss of native habitat caused by nonnative ungulates (pigs, goats, mouflon sheep, axis deer, and cattle). Nonnative ungulates also impact the habitat through predation and trampling. Without this special management, habitat containing the features that are essential for the conservation of these species will continue to be degraded and destroyed. All designated critical habitat requires active management to address the ongoing degradation and loss of native habitat caused by nonnative plants. Special management is also required to prevent the introduction of new nonnative plant species into native habitats. Particular attention is required in nonnative plant control efforts to avoid creating additional disturbances that may facilitate the further introduction and establishment of invasive plant seeds. Precautions are also required to avoid the inadvertent trampling of listed plant species in the course of management activities. The active control of nonnative plant species would help to address the threat posed by fire to 31 of the designated ecosystem critical habitat units in particular: Maui-Coastal—Units 4 through 7; Maui-Lowland Dry—Units 1 through 6; Maui-Lowland Mesic—Units 1 and 2; Maui-Montane Mesic—Units 1, 2, and 5; Maui-Dry Cliff—Units 1, 5, and 7; Kahoolawe-Coastal—Units 1 through 3; Kahoolawe-Lowland Dry—Units 1 and 2; Molokai-Coastal—Units 1, 2, 3, 6, and 7; Molokai-Lowland Dry—Units 1 and 2; and Molokai-Lowland Mesic— Unit 1. This threat is largely a result of the presence of nonnative plant species such as the grasses Andropogon virginicus (broomsedge), Cenchrus spp. (sandbur, buffelgrass), and Melinis minutiflora (molasses grass), that increase the fuel load and quickly regenerate after a fire. These nonnative grass species can outcompete native plants that are not adapted to fire, creating a grass-fire cycle that alters ecosystem functions (D'Antonio and Vitousek 1992, pp. 64–66; Brooks et al. 2004, p. 680). Nine of the ecosystem critical habitat units (Maui-Lowland Wet—Units 1 and 4; Maui-Montane Wet—Units 1 through 3; Maui-Montane Mesic—Unit 2; MauiWet Cliff—Units 6 and 7; and MolokaiMontane Wet—Unit 1) may require special management to reduce the threat of landslides, rockfalls, and flooding. These threaten to further degrade habitat conditions in these units and have the potential to eliminate some occurrences of 50 plant species (e.g., Adenophorus periens, Alectryon macrococcus, Asplenium peruvianum var. insulare, Bidens campylotheca ssp. pentamera, B. campylotheca ssp. waihoiensis, B. conjuncta, B. wiebkei, Bonamia menziesii, Clermontia oblongifolia ssp. brevipes, C. oblongifolia ssp. mauiensis, C. samuelii, Ctenitis squamigera, Cyanea asplenifolia, C. copelandii ssp. haleakalaensis, C. duvalliorum, C. hamatiflora ssp. hamatiflora, C. horrida, C. kunthiana, C. magnicalyx, C. mannii, C. maritae, C. mceldowneyi, C. profuga, C. solanacea, Cyrtandra filipes, C. munroi, Diplazium molokaiense, Dubautia plantaginea ssp. humilis, Geranium hanaense, G. multiflorum, Hesperomannia arborescens, Huperzia mannii, Kadua laxiflora, Lysimachia lydgatei, L. maxima, Melicope balloui, M. ovalis, Phyllostegia hispida, P. mannii, P. pilosa, Plantago princeps, Platanthera holochila, Pteris lidgatei, Remya mauiensis, Santalum haleakalae var. lanaiense, Schiedea laui, Stenogyne bifida, S. kauaulaensis, Wikstroemia villosa, and Zanthoxylum hawaiiense) found on steep slopes and cliffs, or in narrow gulches.

Life History

Feeding Narrative

Adult: Partulina semicarinata is arboreal and nocturnal, and grazes on fungi and algae growing on leaf surfaces (Pilsbry and Cooke 1912–1914, p. 103) (USFWS, 2016). Inhabits wet forests on the island of Lanai on tree trunks, stems and leaves that have the fungi snails eat. 1994 field surveys conducted at 870 to 1018 meters in elevation found populations amoungst the following native vegetation :ohia lehua (METROSIDEROS POLYMORPHA), kanawao (BROUSSAISIA ARGUTA), kopiko (PSYCHOTRIA sp.), COPROSMA sp., pelea (MELICOPE sp.), and dead hapuu fern (CIBOTIUM GLAUCUM). Alien vegetation included: guava (PSIDIUM GUAJAVA), New Zealand flax (PHORMIUM TENOX), and New Zealand ti (CORDYLINE AUSTRALIS). (USFWS, 1997).Forest - Hardwood (NatureServe, 2015)

Reproduction Narrative

Adult: Adults require 4-7 years to reach sexual maturity; reproductive rates are low; eggs are not laid as in most terrestrial snails, rather the young emerge fully developed from the parent; dispersal is very limited, with most individuals remaining in the tree or bush on which they were born. All of these traits make these snails very sensitive to any event that could lead to a reduction or loss of reproductive individuals. (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Unknown (Natureserve, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Inhabits wet forests on the island of Lanai on tree trunks, stems and leaves that have the fungi snails eat. 1994 field surveys conducted at 870 to 1018 meters in elevation found populations amoungst the following native vegetation :ohia lehua (METROSIDEROS POLYMORPHA), kanawao (BROUSSAISIA ARGUTA), kopiko (PSYCHOTRIA sp.), COPROSMA sp., pelea (MELICOPE sp.), and dead hapuu fern (CIBOTIUM GLAUCUM). Alien vegetation included: guava (PSIDIUM GUAJAVA), New Zealand flax (PHORMIUM TENOX), and New Zealand ti (CORDYLINE AUSTRALIS). (USFWS, 1997) (NatureServe, 2015). Clumped spatial arrangements of the population, high ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the specific habitat requirements of the species (including apparent elevation restrictions) and the relatively low number of known populations.

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: Unlikely (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Adults require 4-7 years to reach sexual maturity; reproductive rates are low; eggs are not laid as in most terrestrial snails, rather the young emerge fully developed from the parent; dispersal is very limited, with most individuals remaining in the tree or bush on which they were born. All of these traits make these snails very sensitive to any event that could lead to a reduction or loss of reproductive individuals (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Species Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (inferred from NatureServe, 2015)

Representation:

Low (inferred from NatureServe, 2015)

Redundancy:

Low (inferred from NatureServe, 2015)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Population Narrative:

Random environmental events (e.g., hurricanes and droughts) could affect the continued existence of the Lanai tree snails due to the small numbers of populations and individuals that remain. Adults require 4-7 years to reach sexual maturity; reproductive rates are low; eggs are not laid as in most terrestrial snails, rather the young emerge fully developed from the parent; dispersal is very limited, with most individuals remaining in the tree or bush on which they were born. All of these traits make these snails very sensitive to any event that could lead to a reduction or loss of reproductive individuals. While there are no historic population estimates, qualitative accounts of tree snails indicate that they were widespread and abundant in their habitat, with any single species probably numbering in the tens of thousands. In 1994, field surveys were conducted throughout the remaining native habitat (820-1,018 meters (m) (2,690-3,339 feet (ft)) in elevation) of the historic range, indicating that there are very few remaining individuals restricted to small isolated populations (Hadfield 1994). Decline of >90% At the 16 locations a total of 175 individuals of various age classes were recorded (USFWS, 1997; 2003).

Each location only contained one to two adults. Partulina variabilis was observed at 16 locations during 1994 field surveys, and a total of 175 individuals were seen (28 adult, 111 juvenile, and 36 newborn snails) (NatureServe, 2015). Low resiliency, representation and redundancy are based on the number of use sites and their relatively limited geography the species is known to inhabit as well as the overall population size.

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Adverse impacts on habitat of this species have been identified from nonnative animals (axis deer and mouflon), drought, and hurricanes. The effects by nonnative animals includes the destruction of vegetative cover; trampling of plants and seedlings; direct consumption of native vegetation; soil disturbance; dispersal of alien plant seeds on hooves and coats, and through the spread of seeds in feces; and creation of open, disturbed areas conducive to further invasion by nonnative pest species. Drought destabilize substrates, damage and destroy individual plants, and alter hydrological patterns, which result in changes to native plant and animal communities. Hurricanes adversely impact native Hawaiian terrestrial habitat by destroying native vegetation, opening the canopy and thus modifying the availability of light, and creating disturbed areas conducive to invasion by nonnative pest species. Potential adverse impacts from climate change have also been identified (USFWS, 2013).

Stressor: Overutilization (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The Hawaiian tree snails are vulnerable to the impacts of overutilization due to collection for trade or market (USFWS, 2013).

Stressor: Disease or predation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Disease is a potential threat to this tree snail, as recovery of this species likely will include captive propagation and disease is suspected to be a cause of currently unsuccessful captive propagation. However, the Services have no evidence to suggest that disease is acting on the wild populations such that it may be considered a significant threat to the species. Predation and herbivory by nonnative species (rats, Jackson's chameleon, flatworms (potentially), and snails) is considered an ongoing threat throughout the species range (USFWS, 2013).

Stressor: Small populations (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Partulina semicarinata faces the threat of limited numbers (i.e., there are fewer than 50 individuals in the wild). The number of individuals has declined by approximately 50 percent

between 1993 and 2005 at known locations. The only known wild populations face serious threats from predation by nonnative rats, Jackson's chameleons, and snails (USFWS, 2013).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Recovery Actions:

- A recovery plan has not been initiated for this species.

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/ecp0/. Accessed July 2016

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

USFWS. 2012. Endangered and Threatened Wildlife and Plants

Listing 38 Species on Molokai, Lanai, and Maui as Endangered and Designating Critical Habitat on Molokai, Lanai, Maui, and Kahoolawe for 135 Species. Proposed rule. 81 FR 17789 - 18110 (Monday, June 11, 2012).

U.S. Fish and Wildlife Service. 2016. Endangered and Threatened Wildlife and Plants

Designation and Nondesignation of Critical Habitat on Molokai, Lanai, Maui, and Kahoolawe for 135 Species

Final Rule . 81 FR 17790-18110 (March 30, 2016).

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Final Rule. FR Vol. 81, No. 61. Pages 17790-18110

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

USFWS. 2013. Determination of Endangered Status for 38 Species on Molokai, Lanai, and Maui

Final Rule. 78 Federal Register 102, May 28, 2013. Pages 32014 - 32065.

SPECIES ACCOUNT: *Partulina variabilis* (Lanai tree snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 06/27/2013; Pacific Region (R1) (USFWS, 2016)

Physical Description

The shell may coil to the right (dextral) or left (sinistral), and both types can be found within a single population. The oblong to ovate shells of the adult are 0.5 to 0.6 in (14 to 16 mm) long, have 5 to 7 whorls, and have a white base color with no bands or a variable number of spiral bands around the shells (Pilsbry and Cooke 1912–1914, pp. 67, 83–86) (USFWS, 2012).

Taxonomy

Partulina variabilis (Lanai tree snail, pupu kani oe), a member of the family Achatinellidae and the endemic Hawaiian subfamily Achatinellinae, is known only from the island of Lanai (Pilsbry and Cooke 1912–1914, p. 86) (USFWS, 2016).

Historical Range

See current range/distribution

Current Range

Historic populations of P. variabilis were restricted to the wet and mesic ohia forests on the island of Lanai. Endemic to the remaining wet forests on the Hawaiian island of Lanai. This species was originally described from Ranai [Lanai], Hawaiian Islands (Johnson, 1996).

Critical Habitat Designated

Yes; 3/30/2016.

Legal Description

On March 30, 2016, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Partulina variabilis (Lanai tree snail) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes an unknown number of critical habitat units (CHUs), in Hawaii (81 FR 17790-18110).

Critical Habitat Designation

The critical habitat designation for Partulina variabilis includes an unknown number of CHUs in Maui County, Hawaii. The number of CHUs is unknown because detailed CHU information is not available fot the island of Lanai (81 FR 17790-18110).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Partulina variabilis critical habitat consists of three components. Lowland wet (Lanai), Montane wet (Lanai) and Wet cliff (Lanai) (81 FR 17790-18110):

Ecosystem: Lowland Wet. Elevation: <3,330 ft (<1,000 m). Annual precipitation: 50–75 in (130–190 cm). Substrate: Clays; ashbeds; deep, well drained soils; lowland bogs. Canopy: Antidesma, Metrosideros, Myrsine, Pisonia, Psychotria. Subcanopy: Cibotium, Claoxylon, Kadua, Melicope. Understory: Alyxia, Cyrtandra, Dicranopteris, Diplazium, Machaerina, Microlepia.

Ecosystem: Montane Wet. Elevation: 3,300–6,500 ft (1,000–2,000 m). Annual precipitation: >75 in (>190 cm). Substrate: Well-developed soils, montane bogs. Canopy: Acacia, Charpentiera, Cheirodendron, Metrosideros. Subcanopy: Broussaisia, Cibotium, Eurya, Ilex, Myrsine. Understory: Ferns, Carex, Coprosma, Leptecophylla, Oreobolus, Rhynchospora, Vaccinium.

Ecosystem: Wet Cliff. Elevation: unrestricted. Annual precipitation: >75 in (>190 cm). Substrate: >65 degree slope, shallow soils, weathered lava. Canopy: None. Subcanopy: Broussaisia, Cheirodendron, Leptecophylla, Metrosideros. Understory: Bryophytes, Ferns, Coprosma, Dubautia, Kadua, Peperomia.

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 that are essential to the conservation of the species and which may require special management considerations or protection. In identifying critical habitat in occupied areas, we determine whether those areas that contain the features essential to the conservation of the species require any special management actions. Although the determination that special management may be required is not a prerequisite to designating critical habitat in unoccupied areas, special management is needed throughout all of the critical habitat units in this final rule. The following discussion of special management needs is therefore applicable to each of the Maui Nui species for which we are designating critical habitat in this rule. In this final rule, we are designating critical habitat for 125 of the 135 species for which we proposed critical habitat. For the reasons described below (see Exclusions Based on Other Relevant Factors), we are not designating critical habitat for eight plants (Abutilon eremitopetalum, Cyanea gibsonii, Kadua cordata ssp. remyi, Labordia tinifolia var. lanaiensis, Pleomele fernaldii, Portulaca sclerocarpa, Tetramolopium lepidotum ssp. lepidotum, and Viola lanaiensis) and two tree snails (Partulina semicarinata and P. variabilis). The 125 species for which we are designating critical habitat include 108 plant and animal species that are currently found in the wild on Molokai, Maui, and Kahoolawe; (10 plant species which were historically found on one or more of these islands, but are currently found only on other Hawaiian Islands (Adenophorus periens, Clermontia peleana, Cyanea grimesiana ssp. grimesiana, Cyperus trachysanthos, Eugenia koolauensis, Gouania vitifolia, Isodendrion pyrifolium, Kadua coriacea, Nototrichium humile, and Solanum incompletum), 6 plant species that may not be currently extant in the wild (Acaena exigua, Cyanea glabra, Phyllostegia bracteata, P. haliakalae, Schiedea jacobii, and Tetramolopium capillare), and 1 plant species, Kokia cookei, which exists only in cultivation. For each of the 108 species currently found in the wild on Molokai, Maui, and Kahoolawe, we have determined that the features essential to their conservation are those required for the successful functioning of the ecosystem(s) in which they occur (see Tables 5 and 6, above). As described earlier, in some cases, additional species-specific primary constituent elements were also identified (see Table 6, above). Special management considerations or protections are necessary throughout the critical habitat areas designated here to avoid further degradation or destruction of the habitat that provides those features essential to their conservation. The primary threats to the physical or biological features essential to the conservation of all of these species include habitat destruction and modification by nonnative ungulates, competition with nonnative species, hurricanes, landslides, rockfalls, flooding, fire, drought, and climate change. Additionally, the rosy wolf snail poses a threat to the Newcomb's tree snail and mosquito-borne diseases pose threats to the two forest birds. The reduction of these threats will require the implementation of special management actions within each of the critical habitat areas identified in this final rule. All designated critical habitat requires active management to address the ongoing degradation and loss of native habitat caused by nonnative ungulates (pigs, goats, mouflon sheep, axis deer, and cattle). Nonnative ungulates also impact the habitat through predation and trampling. Without this special management, habitat containing the features that are essential for the conservation of these species will continue to be degraded and destroyed. All designated critical habitat requires active management to address the ongoing degradation and loss of native habitat caused by nonnative plants. Special management is also required to prevent the introduction of new nonnative plant species into native habitats. Particular attention is required in nonnative plant control efforts to avoid creating additional disturbances that may facilitate the further introduction and establishment of invasive plant seeds. Precautions are also required to avoid the inadvertent trampling of listed plant species in the course of management activities. The active control of nonnative plant species would help to address the threat posed by fire to 31 of the designated ecosystem critical habitat units in particular: Maui-Coastal—Units 4 through 7; Maui-Lowland Dry—Units 1 through 6; Maui-Lowland Mesic—Units 1 and 2; Maui-Montane Mesic—Units 1, 2, and 5; Maui-Dry Cliff—Units 1, 5, and 7; Kahoolawe-Coastal—Units 1 through 3; Kahoolawe-Lowland Dry—Units 1 and 2; Molokai-Coastal—Units 1, 2, 3, 6, and 7; Molokai-Lowland Dry—Units 1 and 2; and Molokai-Lowland Mesic— Unit 1. This threat is largely a result of the presence of nonnative plant species such as the grasses Andropogon virginicus (broomsedge), Cenchrus spp. (sandbur, buffelgrass), and Melinis minutiflora (molasses grass), that increase the fuel load and quickly regenerate after a fire. These nonnative grass species can outcompete native plants that are not adapted to fire, creating a grass-fire cycle that alters ecosystem functions (D'Antonio and Vitousek 1992, pp. 64–66; Brooks et al. 2004, p. 680). Nine of the ecosystem critical habitat units (Maui-Lowland Wet—Units 1 and 4; Maui-Montane Wet—Units 1 through 3; Maui-Montane Mesic—Unit 2; MauiWet Cliff—Units 6 and 7; and MolokaiMontane Wet—Unit 1) may require special management to reduce the threat of landslides, rockfalls, and flooding. These threaten to further degrade habitat conditions in these units and have the potential to eliminate some occurrences of 50 plant species (e.g., Adenophorus periens, Alectryon macrococcus, Asplenium peruvianum var. insulare, Bidens campylotheca ssp. pentamera, B. campylotheca ssp. waihoiensis, B. conjuncta, B. wiebkei, Bonamia menziesii, Clermontia oblongifolia ssp. brevipes, C. oblongifolia ssp. mauiensis, C. samuelii, Ctenitis squamigera, Cyanea asplenifolia, C. copelandii ssp. haleakalaensis, C. duvalliorum, C. hamatiflora ssp. hamatiflora, C. horrida, C. kunthiana, C. magnicalyx, C. mannii, C. maritae, C. mceldowneyi, C. profuga, C. solanacea, Cyrtandra filipes, C. munroi, Diplazium molokaiense, Dubautia plantaginea ssp. humilis, Geranium hanaense, G. multiflorum, Hesperomannia arborescens, Huperzia mannii, Kadua laxiflora, Lysimachia lydgatei, L. maxima, Melicope balloui, M. ovalis, Phyllostegia hispida, P. mannii, P. pilosa, Plantago princeps, Platanthera holochila, Pteris lidgatei, Remya mauiensis, Santalum haleakalae var. lanaiense, Schiedea laui, Stenogyne bifida, S. kauaulaensis, Wikstroemia villosa, and Zanthoxylum hawaiiense) found on steep slopes and cliffs, or in narrow gulches.

Life History

Feeding Narrative

Adult: Partulina variabilis is arboreal and nocturnal, and grazes on fungi and algae growing on leaf surfaces (Pilsbry and Cooke 1912-1914, p. 103) (USFWS, 2016). Inhabits wet forests on the island of Lanai on tree trunks, stems and leaves that have the fungi snails eat. 1994 field surveys conducted at 870 to 1018 meters in elevation found populations amoungst the following native vegetation :kanawao (BROUSSAISIA ARGUTA), kopiko (PSYCHOTRIA sp.), COPROSMA sp., pelea (MELICOPE sp.), and dead hapuu fern (CIBOTIUM GLAUCUM). Alien vegetation included: guava (PSIDIUM GUAJAVA), New Zealand flax (PHORMIUM TENOX), and New Zealand ti (CORDYLINE AUSTRALIS). (USFWS, 1997). (NatureServe, 2015).

Reproduction Narrative

Adult: Adults require 4-7 years to reach sexual maturity; reproductive rates are low; eggs are not laid as in most terrestrial snails, rather the young emerge fully developed from the parent; dispersal is very limited, with most individuals remaining in the tree or bush on which they were born. All of these traits make these snails very sensitive to any event that could lead to a reduction or loss of reproductive individuals. (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Unknown (Natureserve, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Species inhabits wet forests on the island of Lanai on tree trunks, stems and leaves that have the fungi snails eat. 1994 field surveys conducted at 870 to 1018 meters in elevation found populations amongst the following native vegetation :kanawao (BROUSSAISIA ARGUTA), kopiko (PSYCHOTRIA sp.), COPROSMA sp., pelea (MELICOPE sp.), and dead hapuu fern (CIBOTIUM GLAUCUM). Alien vegetation included: guava (PSIDIUM GUAJAVA), New Zealand flax (PHORMIUM TENOX), and New Zealand ti (CORDYLINE AUSTRALIS). (USFWS, 1997).F orest - Hardwood (NatureServe, 2015). Clumped spatial arrangements of the population, high ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the specific habitat requirements of the species (including apparent elevation restrictions) and the relatively low number of known populations.

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: Unlikely (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Adults require 4-7 years to reach sexual maturity; reproductive rates are low; eggs are not laid as in most terrestrial snails, rather the young emerge fully developed from the parent; dispersal is very limited, with most individuals remaining in the tree or bush on which they were born. All of these traits make these snails very sensitive to any event that could lead to a reduction or loss of reproductive individuals (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Species Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (inferred from NatureServe, 2015)

Representation:

Low (inferred from NatureServe, 2015)

Redundancy:

Low (inferred from NatureServe, 2015)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Population Narrative:

Random environmental events (e.g., hurricanes and droughts) could affect the continued existence of the Lanai tree snails due to the small numbers of populations and individuals that remain. Adults require 4-7 years to reach sexual maturity; reproductive rates are low; eggs are not laid as in most terrestrial snails, rather the young emerge fully developed from the parent; dispersal is very limited, with most individuals remaining in the tree or bush on which they were born. All of these traits make these snails very sensitive to any event that could lead to a reduction or loss of reproductive individuals. While there are no historic population estimates, qualitative accounts of tree snails indicate that they were widespread and abundant in their habitat, with any single species probably numbering in the tens of thousands. In 1994, field surveys were conducted throughout the remaining native habitat (820-1,018 meters (m) (2,690-3,339 feet (ft)) in elevation) of the historic range, indicating that there are very few remaining individuals restricted to small isolated populations (Hadfield 1994). Decline of >90% At the 16 locations a total of 175 individuals of various age classes were recorded (USFWS, 1997; 2003). Each location only contained one to two adults. Partulina variabilis was observed at 16 locations during 1994 field surveys, and a total of 175 individuals were seen (28 adult, 111 juvenile, and 36 newborn snails) (NatureServe, 2015). Low resiliency, representation and redundancy are based on the number of use sites and their relatively limited geography the species is known to inhabit as well as the overall population size.

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Adverse impacts on habitat of this species have been identified from nonnative animals (axis deer and mouflon), drought, and hurricanes. The effects by nonnative animals includes the destruction of vegetative cover; trampling of plants and seedlings; direct consumption of native vegetation; soil disturbance; dispersal of alien plant seeds on hooves and coats, and through the spread of seeds in feces; and creation of open, disturbed areas conducive to further invasion by nonnative pest species. Drought destabilize substrates, damage and destroy individual plants, and alter hydrological patterns, which result in changes to native plant and animal communities. Hurricanes adversely impact native Hawaiian terrestrial habitat by destroying native vegetation, opening the canopy and thus modifying the availability of light, and creating disturbed areas conducive to invasion by nonnative pest species. Potential adverse impacts from climate change have also been identified (USFWS, 2013).

Stressor: Overutilization (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The Hawaiian tree snails are vulnerable to the impacts of overutilization due to collection for trade or market (USFWS, 2013).

Stressor: Disease or predation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Disease is a potential threat to this tree snail, as recovery of this species likely will include captive propagation and disease is suspected to be a cause of currently unsuccessful captive propagation. However, the Services have no evidence to suggest that disease is acting on the wild populations such that it may be considered a significant threat to the species. Predation and herbivory by nonnative species (rats, Jackson's chameleon, flatworms (potentially), and snails) is considered an ongoing threat throughout the species range (USFWS, 2013).

Stressor: Small populations (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Partulina variabilis faces the threat of limited numbers (i.e., there are fewer than 50 individuals in the wild). The number of individuals has declined by approximately 50 percent

between 1993 and 2005 at known locations. The only known wild populations face serious threats from predation by nonnative rats, Jackson's chameleons, and snails (USFWS, 2013).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Recovery Actions:

- A recovery plan has not been initiated for this species.

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SPECIES ACCOUNT: *Patera clarki nantahala* (Noonday globe)

Species Taxonomic and Listing Information

Listing Status: Threatened August 2, 1978; Southeast Region (R4) (USFWS 2013)

Physical Description

Mesodon claki nantahala has a subglobose, imperforate shell of about 5 1/2 whorls. It measures 17 to 18 mm in width and because of its depressed spire is only 11 mm in height. The shell is reddish and can be quite bright when fresh. The lip of the aperture is sharply reflected and the peristome is white. The peristome of the basal area of the aperture is thickened to form an almost blade-like tooth (USFWS 1984).

Taxonomy

Clench and Banks (1932) named this taxon Polygyra (Triodopsis) nantahala. Pilsbry (1940) later relegated it to a subspecies of Mesodon clarki. Emberton (1991) reclassifed Mesodon clarki to Patera clarki (USFWS 1984).

Historical Range

See current range

Current Range

The noonday globe snail is known from only about two miles (3.2 kilometers) of high cliffs within the Nantahala Gorge in Western North Carolina (USFWS 1984). The noonday globe is known to be endemic only to the southeast side of the Nantahala River Gorge in the Nantahala National Forest, Swain County, North Carolina (Service 1984; J. Fridell, Service, Asheville, NC, personal observation 1985, 1993, 2012 and 2013) (USFWS 2013).

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Nothing is known about the snail's food preferences or feeding behavior (USFWS 1984).

Reproduction Narrative

Adult: Unknown (USFWS 1984).

Geographic or Habitat Restraints or Barriers

Adult: Occurs at elevations between 1900 - 3100 ft (USFWS 1984)

Site Fidelity

Adult: High (inferred from USFWS 1984)

Habitat Narrative

Adult: It is known from high cliffs (1900 to 3100 feet, in a half mile stretch) along the southeast bank of the Nantahala River in the Nantahala Gorge. Cliffs are mesic, interrupted frequently by small streams and waterfalls, and there is much exposed rock and the forest floor often has a thick humus layer (USFWS, 1984). High site fidelity is inferred based on specific site location (inferred from USFWS 1984).

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS 1984)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS 1984)

Dispersal

Adult: Low (inferred from USFWS 1984)

Immigration/Emigration

Adult: No (inferred from USFWS 1984)

Dispersal/Migration Narrative

Adult: Low mobility, non-migratory, low dispersal and no immigration/emigration are inferred based on species restricted habitat/location and species method of locomotion (inferred from USFWS 1984).

Population Information and Trends

Population Trends:

Decreasing (USFWS 2013)

Species Trends:

Decreasing (USFWS 2013)

Redundancy:

Low (inferred from USFWS 2013)

Number of Populations:

One (USFWS 1984)

Population Size:

Unknown (USFWS 1984)

Population Narrative:

Single population in a small geographic area (USFWS 1984). Although the majority of the species' habitat occurs within the boundaries of Nantahala National Forest, loss of habitat associated with development of adjacent private lands and private inholdings, highway maintenance activities, spread of invasive, non-native vegetation and prolonged drought appear to have reduced the species' range and numbers (USFWS 2013).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The primary factors affecting and/or threatening the noonday globe and its habitat are associated with commercial development (off of USFS lands) at the northern end of the gorge, and the NCDOT's maintenance of US Highway 19, which runs between the Nantahala River and the southeast slope of the Nantahala Gorge. Private lands within the gorge continue to be developed, primarily to cater to rafters, kayakers, hikers and other recreational users. Forest clearing and disturbance associated with this development results in the direct loss of noonday globe habitat and appears to be contributing to encroachment of kudzu, Japanese honeysuckle, and other invasive, exotic plants that eliminate suitable habitat for the snail within disturbed areas of the gorge. Also, vegetative clearing associated with the NCDOT's routine right-ofway and ditch maintenance along US Highway 19 within the gorge adversely affects noonday globe habitat in a narrow corridor along the highway and also appears to be contributing to the spread of invasive, non-native plants within the gorge. In addition, because of the extremely restricted range of the noonday snail, a forest fire or other significant impact affecting the health of the forest canopy or understory, and/or moisture levels on the southeastern slope of the Nantahala Gorge could have a devastating effect on the status of the snail and could potentially result in the species' extirpation (USFWS, 2013).

Stressor: Wildfire, drought, and exotic insect tree pests (USFWS, 2013).
Exposure:
Response:
Consequence:
Narrative: Because the noonday globe requires cool, moist habitat, wildfire, drought, and exotic insect tree pests continue to pose a significant threat to the species. Persistent (summer of 2007-spring 2009), exceptional drought conditions resulted in at least a temporary loss of habitat of the species. The extent of impacts on population levels and reproduction is currently unknown and cannot be determined until conditions improve (USFWS, 2013).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Delisting Criteria:
1. Patera (=Mesodon) clarki nantahala and its habitat are protected from human-related or foreseeable natural threats that would jeopardize the species' existence (USFWS 2013).

2. A population monitoring program is established and conducted for at least five years to establish distribution and baseline abundance for the species and that no downward trend is evident (USFWS 2013).

3. A means is established to assure that population monitoring will be conducted periodically after delisting (USFWS 2013).

4. Collection of the species for scientific or other purposes is controlled or is proven not to threaten the species' continued existence (USFWS 2013).

Conservation Measures and Best Management Practices:

- 1. Improve planning, coordination, and efficacy of recovery activities with key partners (e.g., USFS, NCWRC, NCNHP, local conservation NGOs, researchers, etc.) by meeting at least biennially to share information and review and recommend priority recovery actions (USFWS 2013).
- 2. Formalize and implement a detailed population and habitat monitoring plan for the species (USFWS 2013).
- 3. Continue analyzing threats to the species and measures for off-setting these threats (USFWS 2013).
- 4. Continue surveys for previously unknown occurrences of the species (USFWS 2013).
- 5. Determine intra- and inter-population genetics. This information is necessary to estimate the relative viability of the population(s) (USFWS 2013).
- 6. Continue habitat use and life history studies of the species (USFWS 2013).
- 7. Continue working with partners to control the spread of non-native species and restore degraded habitat (USFWS 2013).

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SPECIES ACCOUNT: *Physa natricina* (Snake River physa snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; Pacific Region (R1) (USFWS, 2016)

Physical Description

The Snake River physa snail (Haitia (Physa) natricina) is a freshwater mollusk found in the middle Snake River of southern Idaho. It has an ovoid shell that is amber to brown in color, and has 3 to 3.5 whorls (curls or turns in the shell). The physa can reach a maximum length of about 6.5 millimeters (USFWS, 2016).

Taxonomy

The Snake River physa is believed to have evolved in the Pliocene to Pleistocene lakes and rivers of northern Utah and southeastern Idaho. While much information exists on the family Physidae, very little is known about the biology or ecology of this species (USFWS, 2016).

Current Range

Existing populations of the Snake River physa are known only from the Snake River in central and south-southwest Idaho and a small portion of Oregon (see Figure 1, p. 7, 5-Year Status Review for Snake River physa), with the exception of two live specimens recovered from the Bruneau River arm of C.J. Strike Reservoir about four miles upstream from the Snake River portion of the reservoir. In the 1995 Snake River Species Aquatic Recovery Plan, the Service reported (p. 8) that the "modern" range of the Snake River physa extended within the Snake River from river kilometer (RK) 784 (river mile [RM] 487) near Grandview upstream to the Hagerman Reach (RK 922 (RM 573)), with a possible colony downstream of Minidoka Dam (RK 1086 (RM 675)). Surveys conducted by the U.S. Bureau of Reclamation (BoR) from 2006 through 2012 and subsequent analysis in 2009 of live snails recovered by the Idaho Power Company (IPC) in collections between 1995 and 2003 have established the Snake River physa's current distribution to be from RK 592 (RM 368) near Ontario, Oregon, upstream to Minidoka Dam RK 1086 (RM 675)). The Bruneau Arm of C.J. Strike Reservoir has not been resurveyed for Snake River physa since the identification in 2009 of two live specimens recovered there in 2002. (The additional site in the Bruneau River arm of C.J. Strike Reservoir was identified when the shell morphology (diagnostic of Snake River physa) of the two live specimens was found to match that of specimens with similar morphology also confirmed as Snake River physa by DNA analysis.) Within this 494 km (307 mi) range, the species remains rare with only 385 confirmed live-when-collected specimens taken over a 53-year period between 1959 and 2012. In addition, BoR began collecting data on Snake River physa in 2012 between Minidoka Dam and RK 1079 (RM 670.4), with surveys continuing in 2013 and 2014. BoR has recovered the following numbers of live Snake River physa: 45 in 2012; 92 in 2013; and 13 in 2014. While live Snake River physa have been collected from the same survey transects in successive years (2006-2014) downstream of Minidoka Dam, the species has not been regularly or reliably located throughout the rest of its range. Snake River physa have not been found in the reaches between Lower Salmon Falls Dam and the Minidoka reach (RK 922-1068 (RM 573- 663.5)), although surveys in this area have been rare and sporadic. Snake River physa have not been collected in the area of the type locality (RK 916-917 (RM 569-570)) since 1988. The species was first documented downstream of C.J. Strike Reservoir during an inspection (in 2009) of samples collected by IPC between 1995and 2003. Fifty-two live-when-captured individuals (out of over 19,000 live physids recovered) were found to match the morphological characteristics of Snake River physa. A subset (15 individual snails) of these live-when-captured individuals was subsequently confirmed to be Snake River physa through genetic analysis. At this time the Service considers the colonies downstream of Minidoka Dam as the upstream-most extent of the species' current range. Previous identification of Snake River physa from surveys upstream of Minidoka Dam have not been confirmed through genetic analysis. Surveys by the BoR in 2011 upstream of Minidoka Dam and downstream of American Falls Dam (approximately RK 1135 - 1144 (RM 705 - 711)) did not yield any live Snake River physa or its shells. In addition, a 2014 review of a large gastropod collection conducted in 2004 in the Snake River and tributaries upstream of American Falls Reservoir (RK 1209 (RM 751)) did not identify any live-when-collected Snake River physa specimens or shells, providing further strong, although not conclusive, evidence that the species may not occur upstream of Minidoka Dam. In summary, the currently confirmed range of the Snake River physa is from RK 1086 (RM 675) at Minidoka Dam downstream to RK 592 (RM 368) near Ontario, Oregon. Within this 494 km (307 mi) range the species is generally rare and occurs in patchy distribution, with only 535 total confirmed live-when-collected specimens taken between 1959 and 2014. The species highest abundance and densities are currently found in the 18.5 km (11.5 mi) river segment downstream of Minidoka Dam. Despite limited efforts to sample for the species from locations where it has been previously collected, Snake River physa has not been reliably collected outside of the Minidoka reach (USFWS, 2016).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Much remains unknown regarding the basic biology of the Snake River physa, including reproduction and life history traits, and diet preferences (USFWS, 2016).

Reproduction Narrative

Adult: Much remains unknown regarding the basic biology of the Snake River physa, including reproduction and life history traits, and diet preferences (USFWS, 2016).

Habitat Narrative

Adult: Analysis of Snake River physa substrate preferences indicates the species selects for gravel to pebble, possibly gravel to cobble, substrates where water velocity keeps the substrate relatively free of fine sediments and macrophyte plant growth. The species has been found at depths between 0.5 to 3 meters. The highest abundance and densities of Snake River physa (between 32 to 64 per square meter) have been found in relatively large, relatively contiguous areas of gravel to pebble beds, in braided areas of the Snake River that are largely absent of fine sediments and macrophytes at depths between 1.5 to 2.5 meters in 18.5 km (11.5 mi) downstream of Minidoka Dam. Average water velocity where the species was found in this reach was 0.57 meters per second. Although the species has been documented at relatively high densities (32-64 individuals per square meter), it has usually been found in diffusely distributed populations, suggesting that the species rarely exhibits high density colony behavior (USFWS, 2016).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (USFWS, 2016)

Dispersal/Migration Narrative

Adult: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Population Information and Trends

Population Trends:

Unknown (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Only three populations are believed to be extant (USFWS, 1995). Currently it is restricted to the Snake River (not in the tributaries) from the vicinity of Bliss to Hammett, Gooding Co., Idaho (Taylor, 2003). Taylor (1988) also cites fossil evidence from Bear Lake, Idaho/Utah; Lake Bonenville, Idaho/Nevada/Utah; Box Elder and Salt Lake Cos., Utah; Lake Thatcher, Utah; and Snake River, Idaho. (NatureServe, 2015). The highest abundance and densities of Snake River physa (between 32 to 64 per square meter) have been found in relatively large, relatively contiguous areas of gravel to pebble beds, in braided areas of the Snake River that are largely absent of fine sediments and macrophytes at depths between 1.5 to 2.5 meters in 18.5 km (11.5 mi) downstream of Minidoka Dam. Average water velocity where the species was found in this reach was 0.57 meters per second. Although the species has been documented at relatively high densities (32-64 individuals per square meter), it has usually been found in diffusely distributed populations, suggesting that the species rarely exhibits high density colony behavior (USFWS, 2016).

Threats and Stressors

Stressor: High nutrient levels (USFWS, 2016)
Exposure:
Response:
Consequence: Habitat degradation
Narrative: High nutrient levels are listed as a threat to this species (USFWS, 2016).

Stressor: Low flows and water velocity (USFWS, 2016)
Exposure:
Response:
Consequence: Sediment deposition/loss of habitat
Narrative: low flows and water velocity during the irrigation season (April 1 to September 30) that lead to sediment deposition and macrophyte growth over preferred substrates, rendering

preferred substrates unsuitable for occupation by the species are listed as a threat to this species (USFWS, 2016).

Stressor: Operation of existing dams
Exposure:
Response:
Consequence:
Narrative: Continued threat – no significant change in the operation of existing dams since 2014 SRP 5-year status review.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Continued threat - no significant change in climate change information since 2014 SRP 5-year status review.

Stressor: Pollution control regulations
Exposure:
Response:
Consequence:
Narrative: Continued threat – no significant change in pollution control regulations since 2014 SRP 5-year status review.

Stressor: Lack of State invertebrate species regulations
Exposure:
Response:
Consequence:
Narrative: Continued threat – no significant change in state of Idaho regulations since 2014 SRP 5-year status review.

Stressor: Small population size, habitat fragmentation, and loss of connectivity
Exposure:
Response:
Consequence:
Narrative: Analyzed in 2014 SRP 5- year status review, but determined not a threat at that time. Data since then indicates it is an increasing threat in 2018 5-year status review

Recovery

Recovery Actions:

- Ensure water quality standards for cold-water biota and habitat conditions so that viable, self-reproducing snail colonies are established in free-flowing mainstem and cold-water spring habitats within specified geographic ranges, or recovery areas, for each of the S species. Snails detected at the sites selected for monitoring will be surveyed on an annual basis to determine population stability and persistence, and verify presence of all life history stages fora minimum of 5 years.

- Develop and implement habitat management plans that include conservation measures to protect cold-water spring habitats occupied by Banbury Springs lanx, Bliss Rapids snail, and Utah valvata snail from further habitat degradation (i.e. diversions, pollution, development) as described in Action #1.
- Stabilize the Snake River Plain aquifer to protect discharge at levels necessary to conserve the listed species cold-water spring habitats.
- Evaluate the effects of non-native flora and fauna on listed species in the Snake River from Ci. Strike Dam to American Falls Dam

Conservation Measures and Best Management Practices:

- Gather, through research and surveys, additional information regarding basic biology and known range. Much remains unknown regarding the basic biology of the Snake River physa, including reproduction and life history traits, and diet preferences. In addition, surveys for presence within their current range have been limited in extent, especially outside of the Minidoka reach. Additional survey effort is needed in areas where they have been recently collected, particularly downstream of C.J. Strike and Swan Falls Dams, and within the Bruneau arm of C.J. Strike Reservoir (USFWS, 2016).
- Given the existing monitoring of Snake River physa below Minidoka Dam is a 5-year effort that was initiated in 2012, we recommend continued monitoring of that population, beyond the present effort, to further track population trends. In addition, if the Snake River physa can be reliably collected outside of the Minidoka reach, a monitoring program should be established in those areas to obtain population trends at a larger, rangewide scale (USFWS, 2016).
- Revise the Snake River Aquatic Species Recovery Plan with objectives and measurable criteria that are specific to the Snake River physa (USFWS, 2016).
- Additional work is needed to address factors that have led to the degradation of the Snake River physa's habitat. Actions may include decreasing nutrients, such as TP, and suspended sediment inputs to the Snake River from certain land uses within its range, while reducing existing substrate embeddedness and excessive macrophyte growth by modifying dam operations to enhance seasonal flows (i.e. increasing river flows during the summer months) in certain areas of their range (USFWS, 2016).
- The USFWS recently collaborated with the Idaho Power Company and U.S. Bureau of Reclamation on development of an environmental DNA (eDNA) marker to be utilized for future Snake River physa presence/absence surveys (Young in litt. 2018). eDNA is DNA that has separated from an organism into their surrounding environment. Water that may contain an organism's DNA can be collected and analyzed to determine if the species is present nearby. Preliminary results indicate this new approach to surveying for the Snake River physa holds promise (Young in litt. 2018) and could ultimately expand survey efforts beyond the time consuming method typically utilized to survey for the species; suction dredging the river bottom (via scuba diving off a boat), sorting material, and identifying individual Snake River physa via morphological or standard DNA testing (USFWS, 2018)..
- Recommendations for Future Actions: 1. Continue monitoring Snake River physa within the Minidoka reach to further track population trends of this important population. 2. Continue targeted surveys outside of the Minidoka reach to further inform our understanding of the species current range. 3. Finalize development of the eDNA marker for the Snake River physa with intention to utilize it as soon as possible. 4. Apply eDNA survey method outside the Minidoka reach, where it has been difficult to confirm species presence, to enhance current distribution information. 5. Investigate possible habitat conditions, or other factors, limiting Snake River physa occupancy

outside of the Minidoka reach. Based on those results, reevaluate recovery actions to address those threats (USFWS, 2018).

References

USFWS. 2016. Status of the Species: Haitia (Physa) natricina (Snake River Physa). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266

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

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SPECIES ACCOUNT: *Planorbella magnifica* (Magnificent ramshorn)

Species Taxonomic and Listing Information

Listing Status: Candidate; (USFWS, 2016)

Physical Description

The following is adapted from Adams 1990a and 1993 and references therein: The magnificent ramshorn is a freshwater snail in the family Planorbidae (Pilsbry 1903), a family of air-breathing snails. It is the largest North American snail in this family. It has a discoidal (i.e., coiling in one plane), relatively thin shell that reaches a diameter commonly exceeding 35 millimeters (mm) (1.38 inches) and heights exceeding 20 mm (0.79 inch). The great width of its shell, in relation to the diameter, makes it easily identifiable at all ages. The shell is brown to horn colored and thin and fragile. The center of the shell is deeply sunken on each side, with coils having steep slopes which form acute to sub-acute angles on the outside edges of the coils. The aperture of the shell is somewhat bell-shaped and very wide, extending beyond the sides of the shell.

Taxonomy

The magnificent ramshorn was described by Pilsbry (1903) from the lower Cape Fear River region of North Carolina. Pilsbry (1903) placed it in the genus Planorbis Muller 1774. Baker (1945) reassigned the species to the genus Helisoma Swainson 1840. He recognized two subgenera under Helisoma Pierosoma Dall 1905 and Planorbella Haldeman 1842 and placed the magnificent ramshorn under Pierosoma. Taylor (1966) subsequently elevated Planorbella to full genus rank and placed the subgenus Pierosoma within it. The species reproductive system (figured by Baker 1945: pl. 31, fig. 20), shell characters, and DNA sequence data all support Planorbella magnifica as a valid species (Bogan et al. 2003, pp. 5 and 6). The Service has reviewed the available taxonomic literature, and is not aware of any challenges to the validity of this species.

Historical Range

The species has been recorded only from Greenfield Lake within the present city limits of Wilmington, New Hanover County, North Carolina (Bartsch 1908, pp. 697 and 698); as well as Orton Pond (Adams and Gerberich 1988, p. 125; Adams 1990a p. 27), Sand Hill Creek Pond (Adams 1993, p. 4) and McKinzie Pond, in Brunswick County, North Carolina (Wood pers. comm. 2004).

Current Range

Available information indicates that the magnificent ramshorn is likely extirpated from the wild. Presently, the only known surviving individuals of the species are being held as part of captive populations; one established and maintained by a private individual at his residence in Pender County, North Carolina, one at NC State Universitys Veterinary Schools Aquatic Epidemiology Conservation Laboratory in Raleigh, North Carolina, and another one at the NCWRCs Watha State Fish Hatchery in Watha, North Carolina.

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Like other members of the Planorbidae family, the magnificent ramshorn is believed to be primarily vegetarian, feeding on submerged aquatic plants, algae, and detritus (decomposing plant material) (Baker 1943, p. 19; Wood 2004, p. 13). Wood (2004, p. 13) observed that the magnificent ramshorn showed a preference for spatterdock, especially the ripe seed head of the plant. In captivity, the species has also been reported to feed on Carolina fanwort (Cabomba caroliniana) (D. DuMond pers. comm. to Adams 1993), algae, detritus, lettuce, and commercial foods containing algae meal (Wood 2004, pp. 1, 7 and 13).

Reproduction Narrative

Adult: Members of the family Planorbidae are hermaphroditic (individuals have both male and female reproductive organs) (Baker 1943, p. 4). However, it is currently unknown whether they selffertilize their eggs, mate with other individuals of the species, or both. Wood (2004, p. 12) reported that, while he has not precisely documented mating, he has observed pairs bonded to one another for more than 15 minutes. It is believed that in the wild the species reaches sexual maturity at two years of age; however, Wood (2004, p. 2) reported that in captivity, possibly due to a supplemental diet, the species can reach sexual maturity during the first year of age. The magnificent ramshorn lays fertilized eggs on the undersides of leaves of aquatic vegetation and shows a preference for spatterdock (Wood 2004, p. 12). In captivity the species has also been reported to lay eggs on any smooth, submerged material, including the sides of containers in which they are held (Wood 2004, p. 12). Wood (2004, p 12; 2010 p. 4) reported egg laying is likely triggered by water temperature and typically begins in April, with maximum egg production occurring during June and July, and likely extends as late as at least October. It is currently unknown how many egg masses can be produced by an individual snail. Typically egg masses typically contain 20 to 30 eggs and, depending on water temperature, eggs hatch within 16 to 25 days (Wood 2010, p. 4), although in 2011 some egg masses hatched within 14 days (Wood pers. comm 2012). While juvenile magnificent ramshorns have eyes, the eyes gradually disappear as the snails grow and adults of the species are blind (Dall 1907, p. 90; Bartsch 1908, p. 698; Adams 1993, P. 18). Dall (1907, p. 90) reported that the life span of the magnificent ramshorn is likely about 2 years; Adams (1993, p. 18) reported that a study of growth rest lines on the shells of available specimens support this conclusion (the species metabolism and growth slow down during the winter months, leaving growth rings similar to growth rings on trees).

Geographic or Habitat Restraints or Barriers

Adult: restricted to relatively shallow, sheltered portions of still or sluggish, freshwater bodies with an abundance and diversity of submerged aquatic vegetation and a circumneutral pH

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Habitat Narrative

Adult: Although the magnificent ramshorn is a large snail, its shell is thin and fragile indicating that it is adapted to lentic (still or slow flowing) aquatic habitats (Bartsch 1908, p. 697; Adams 1993, pp. 2 and 3). Available information indicates that suitable habitat for the species is restricted to relatively shallow, sheltered portions of still or sluggish, freshwater bodies with an abundance and diversity of submerged aquatic vegetation and a circumneutral pH (pH within the range of 6.8 7.5) (Adams 1993, p. 8). The pre-settlement distribution and habitat use of the species is not very well known. The only known records for the species are post-1900 and are from manmade millponds constructed in the 1700s to provide a freshwater source for rice agriculture (Adams 1993, pp. 21 and 22). However, it is highly plausible that the species inhabited beaver ponds, which were plentiful in the region prior to the extirpation of the North American beaver (Castor canadensis) in North Carolina circa 1900 and subsequently persisted in millponds which replicated habitat conditions found in the beaver ponds and offered the only available suitable habitat (Adams 1993 and references therein, p. 22). It is also possible that the species may also have once been a faunal component of sluggish portions of the Cape Fear River proper until natural forces (e.g., sea level rise and changes in the inlet due to storm events) and/or navigational changes, which began as early as 1822, altered salinity regimes, flow and current patterns, and other hydrological conditions. These alterations would have made conditions unsuitable for the snail and limited it to portions of tributary streams providing suitable habitat protected from water quality and hydrological changes occurring elsewhere in the river basin (Adams 1993, pp. 21 and 22). Bartsch (1908, p. 698) reported finding the magnificent ramshorn only in fragrant waterlily (Nymphaea odorata) and pondweed (Potamogeton sp.) beds in cove areas of Greenfield Lake. Adams and Gerberich (1988, p. 125), Adams (1993, p. 8), and Wood (2002, p. 1) also reported finding the species on aquatic vegetation, fragrant waterlily and spatterdock (Nuphar lutem), in similar sheltered habitat in Orton Pond, Sand Hill Creek Pond, and McKinzie Pond, respectively. However, Adams (1993, p. 8) reported that the species appeared to be more generally distributed in Sand Hill Creek Pond than what he observed in Orton Pond. Adams (1993, p. 8) reported that the maximum depth where he found the species in Orton Pond and Sand Hill Creek Pond was approximately one meter. The Planorbidae family of snails is on the whole a distinctly shallow-water group (Baker 1943, p. 17). Salinity and pH also are major factors limiting the distribution of the magnificent ramshorn. Wood (2002, p. 3) reported that captive held magnificent ramshorn snails ceased all activity, withdrew into their shell, and sank to the bottom of their tank within 24 hours of exposure to salinity levels of 1.0 part per thousand (ppt). Within 8 hours they withdrew into their shell and died within 36 hours if not removed from water with a salinity of 5 ppt. Also, Wood (2002, pp. 2 and 3) observed that magnificent ramshorn snails fed and moved around normally in water with a pH of 6.8 to 7.5, but that the snails feeding and other activity would cease altogether at pH levels at or below 6.5 and at or above 8.0. Greenfield Lake (NC Department of Environment and Natural Resources [NCDENR] 2004, p. 331), Orton Pond, Sand Hill Creek Pond (Adams 1993, App. C Field Data Sheets) and McKinzie Pond (Wood pers. comm. 2010) were all reported to have a circumneutral pH, i.e., within the range 6.8 to 7.5. This is higher than typical for many of the water bodies in the region. This is believed to be due to significant input of groundwater from underlying limestone formations in the watersheds of the creeks feeding these impoundments (Adams and Gerberich 1988, p. 125).

Dispersal/Migration

Motility/Mobility

Adult: low mobility

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory

Dispersal

Adult: low

Immigration/Emigration

Adult: no

Dependency on Other Individuals or Species for Dispersal

Adult: not applicable

Dispersal/Migration Narrative

Adult: Does not naturally disperse. All populations are captive.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Resiliency:

Low

Representation:

Low

Redundancy:

Low

Population Growth Rate:

Unknown

Number of Populations:

3 captive populations

Population Size:

Approximately 300

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Low

Adaptability:

Low

Population Narrative:

Currently known only from three established captive populations, one robust population currently comprised of approximately 200+ adults and two small populations of 50+ adults, the magnificent ramshorn is highly vulnerable to extinction. The magnificent ramshorn is believed to be a southeastern North Carolina endemic. The species is known from only four sites in the lower Cape Fear River Basin in North Carolina. Although the complete historic range of the species is unknown, given the size of the species and the fact that it was not reported until 1903 is an indication that the species may have always been rare and localized (Adams 1993, p. 2). Prior to 1992, the magnificent ramshorn had been recorded only from Greenfield Lake, a millpond located on a tributary to the Cape Fear River within the present city limits of Wilmington, New Hanover County, North Carolina (Bartsch 1908, pp. 697 and 698) and Orton Pond (also sometimes referred to as Sprunts Pond), a millpond located on Orton Creek in Brunswick County, North Carolina (Adams and Gerberich 1988, p. 125; Adams 1990a, p. 27). During range-wide surveys in 1992 and 1993, Adams (1993, p. 4) was able to record the species at one additional site, Sand Hill Creek Pond (also referred to as Pleasant Oaks Pond), a millpond on Sand Hill Creek in Brunswick County, North Carolina. In 2004, Andy Wood with the National Audubon Society discovered an additional small occurrence of the species in McKinzie Pond, a millpond on McKinzie Creek, in Brunswick County, North Carolina (Andy Wood, Wilmington, NC, personal communication 2004). Despite searches of well over a hundred potential sites over the last few decades by several different researchers, the species has not been recorded from any other sites. The magnificent ramshorn was last recorded in Greenfield Lake by Bartsch in 1908 (Adams and Gerberich 1988, p. 125; Adams 1990a, p. 27); it was last seen in Sand Hill Creek Pond in 1994 (Wood 2002, p. 9) and the last and only observation of the species in McKinzie Pond was in 2004 (Wood, pers. comm. 2008 and 2010). The species is now believed to be extirpated from these three localities. Adams and Gerberich (1988, p. 125) last observed a living specimen in Orton Pond in 1986. During a subsequent survey in 1987, they were able to find only shell material and reported that much of the aquatic vegetation had died back. Access to the Orton Pond has since been restricted by the landowner (Adams and Gerberich 1988, p. 125; William Adams, Wilmington, NC, pers. comm. 1990 and 2003; Wood pers. comm. 2009) and it is currently unknown if the species still survives in the pond. In 1992, Mr. Andy Wood established a captive, refuge population of the magnificent ramshorn at the North Carolina Aquarium at Fort Fisher, North Carolina, under a captive propagation permit issued by the North Carolina Wildlife Resources Commission (NCWRC). Salt contamination of the aquaria in which the snails were held, believed to have been caused by salt-laden air circulating within the facility, subsequently forced Mr. Wood to establish holding facilities for the snail at his personal residence (Wood 2004, p. 9). Unless the species still survives in Orton Pond, which appears unlikely (see Threats, section A. below) the snails currently being held and propagated by Mr. Wood, NC State University, and NCWRC are currently the only magnificent ramshorn snails known in existence.

Threats and Stressors

Stressor: habitat loss and degradation
Exposure:
Response:
Consequence:

Narrative: Although the complete historic range of the magnificent ramshorn is unknown, available information indicates that the species was likely once an inhabitant of beaver ponds on tributaries in the lower Cape Fear River basin; the species may also have once inhabited backwater and other sluggish portions of the main channel of lower Cape Fear River (Adams 1993, pp 21-22). Beaver pond habitat was eliminated throughout much of the lower Cape Fear River as a result of the extirpation of the beaver due to trapping and hunting during the 19th and early 20th centuries. This, together with draining and destruction of beaver ponds for development, agriculture and other purposes, is believed to have led to a significant decline in the in the snails habitat and significant reduction in its abundance (Wood 2010, pp. 6 and 7). Also, dredging and deepening of the Cape Fear River channel, which began as early as 1822, and opening of the Atlantic Intercoastal Waterway (through Snows Cut) in 1930 for navigational purposes have caused saltwater intrusion, altered the diversity and abundance of aquatic vegetation, and changed flows and current patterns far up the river channel and its lower tributaries (Adams 1993, p 22; Wood 2010, p 7). Under these circumstances, the magnificent ramshorn could have survived only in areas of tributary streams not affected by salt water intrusion and other changes, such as the millponds protected from saltwater intrusion by their dams (Adams 1993, p. 22). The extirpation of the magnificent ramshorn from Greenfield Lake is likely attributable to alteration of the lakes water quality and chemistry resulting from past events. These include breaks in sewerlines on the bottom of the lake; sewage overflow from nearby manholes during storm events; runoff of fertilizers, sediment, toxic chemicals, and other pollutants from the heavy development within the watershed; and/or, efforts by the city to control aquatic plants and algae within the lake (Adams 1990b, p. 104). As a result of heavy nutrient input, Greenfield Lake has become eutrophic and the majority of the aquatic vegetation currently present within the lake is filamentous green algae (Hackney and Brady 1996, p. 19; Adams pers. comm. 2003). Also, the city routinely conducted winter water-level drawdown in the past, in an attempt to control aquatic plant and algae levels within the lake. These drawdowns also likely had an adverse effect on the snail, as well the aquatic vegetation on which it is generally found (Adams 1990b, p. 104). The Sand Hill Creek population of the magnificent ramshorn is believed to have been extirpated in 1996 when the dam on the pond was breached during flooding associated with Hurricane Fran. Drawdown of the pond due to failure of the dam and saltwater intrusion into the pond affected both the magnificent ramshorn as well as the aquatic vegetation providing habitat for the snail, and researchers were unable to locate the snail during a subsequent survey (Wood pers. comm. 1996). This population of the species was last surveyed in 2007 and no evidence of the snail was found (Wood 2010, p. 2). Access by researchers to the pond has since been denied by the landowners (Wood 2010, p. 2). The magnificent ramshorn was last observed in McKinzie Pond in 2004 (Wood pers. comm. 2008). This population of the species is believed to have been extirpated due to saltwater intrusion resulting from prolong drought conditions. The reduction of freshwater levels feeding the stream allowed the tidal flow of saltwater to extend further up McKinzie Creek into the area harboring the snail (Wood pers. comm. 2008). Wood (2010, p. 2) reported that much of the submerged aquatic vegetation that previous flourished at this site, including spatterdock and cabomba, was damaged by saltwater. Access to Orton Pond by researchers surveying for the magnificent ramshorn snail has been restricted since 1990 (Adams and Gerberich 1988, p. 125; Adams pers. comm. 1990 and 2003; Wood pers. comm.. 2009). However, Adams (1993, p. 9) reported that nuisance aquatic vegetation growth was increasing significantly in the pond in the late 1980s, possibly due to increased nutrient supply in the headwater reaches of Orton Creek from golf course and other development activities in the Boiling Springs Lakes area. He also reported that the landowners unsuccessfully attempted to control the aquatic vegetation by a partial drawdown of the lake during the winter 1989/1990, a method extremely detrimental to species like the magnificent ramshorn. It is currently unknown whether the snail survived this drawdown or whether the owners made subsequent attempts to control aquatic vegetation in Orton Pond that may have eliminated the species. The human residential population of Brunswick and New Hanover Counties is rapidly increasing both counties are a popular vacationing and retirement areas. Results of the 2010 census indicate both counties are among the most rapidly developing counties in the state with population growth greater than 25% during the period of 2000-2010 (http://www.wral.com/news/national_world/national/flash/9204746/). Typically as development increases, the input of nutrients (through both surface and groundwater), silt, and other pollutants into the aquatic system increases. Increased input of these pollutants into the stream from point and non-point sources may result in eutrophication, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry. Poorly planned development within the watersheds of streams feeding areas that formerly harbored the magnificent ramshorn or that may provide potential habitat for the species also has the potential to reduce groundwater levels, which could have a serious adverse effect on pH, water hardness, and salinity levels.

Stressor: inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The magnificent ramshorn is currently listed by the state of North Carolina as an endangered species. However, this designation does not protect the species from incidental harm, injury, death (impacts resulting from activities not specifically intend to the harm the species) or provide any protection to the species habitat except on state-owned lands. In addition, neither the state nor the local governments with jurisdictions within the watersheds of streams in the lower Cape Fear River Basin currently have regulations/ordinances that are adequate to protect the species from the effects of agriculture, private forestry, and residential and industrial development activities (e.g., loss of riparian buffers, point and non-point source pollution, and groundwater contamination).

Stressor: climate change
Exposure:
Response:
Consequence:
Narrative: Climate change and sea level rise pose a significant long term threat to the survival of the magnificent ramshorn. As previously noted, the magnificent ramshorn is salt intolerant and saltwater intrusion into its habitat is one of the primary factors that has contributed to its extirpation in the wild. During the past century, sea level has risen by roughly 20.32 centimeters (8 inches) and available information indicates the rate of sea level rise is increasing (US Global Change Research Program [USGCRP] 2009, p. 18). While future rates of sea level rise are uncertain and dependent upon ice sheet response to climate change, continued sea level rise threatens the southeastern US coastal zone with retreat of shorelines, inundation of coastal wetlands and streams, and increased salinity of estuaries, coastal wetlands, and tidal rivers and creeks, pushing freshwater coastal ecosystems further inland. In addition, in the future the southeastern US is threatened with potential higher average temperatures (resulting increased evaporation rates), less frequent rain fall (resulting in potentially more frequent and longer dry periods), and an increase in intensity of storm events, including hurricanes; all of which are likely

to increase the rate and upstream distance of salt water intrusion into coastal streams. Also, higher average temperatures and longer periods between rainfall events, together with increased development and human population levels in Brunswick and New Hanover Counties, will result in an increase demand on freshwater systems for drinking, irrigation, and other water needs, exacerbating the effects of sea level rise on streams in the lower Cape Fear River basin which encompasses the entire known historic range of the magnificent ramshorn (adapted from USGCRP and references therein 2009, pp. 1111-116). During his initial attempt to propagate the agnificent ramshorn, Wood (2004 pp. 8 and 12) documented hybridization between the magnificent ramshorn and the more common marsh ramshorn (P. trivolvis). Although hybridization is not believed to have played a significant role in the extirpation of the magnificent ramshorn from the wild, it could adversely affect efforts to recover the species.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:

- In early 2012, a small (35 individuals) captive population was established at NC State University's Veterinary Schools Aquatic Epidemiology Conservation Laboratory in Raleigh, North Carolina. These captive snails reproduced successfully, however problems with shell quality and high mortality were observed. While the shell quality issues have been successfully mitigated, efforts are still underway to treat possible symptoms that cause the bacteria-based mortality.
- Additional facilities for holding and propagating the magnificent ramshorn at the NCWRCs hatchery in Watha, North Carolina have been established. In 2011, efforts at the Watha hatchery were initially deemed unsuccessful, however a few adult snails survived and were allowed to overwinter (2012) in an established tank. The Hatchery expanded its snail holding capacity in summer 2013 with the addition of a second 600 gallon tank. At this time, the 2012 tank is operational and supporting P. magnifica. SAV introduced in 2012 appears to be thriving and plans are in place to introduce seedling spatterdock to both tanks in spring 2014. Pending results of water quality tests in the second Watha tank, we will also add class of 2012 and 2013 P. magnifica snails to tank two in spring 2014. Both Watha tanks are outfitted with screen covers to exclude leaf litter and large animals.
- In 2008, biologists with the Service, NCWRC, North Carolina Department of Transportation and Andy Wood met to evaluate some of the borrow pit ponds in Brunswick and New Hanover Counties to determine their suitability as habitat for the snail. One pond on a tract of land that remains for sale by the owner in New Hanover County has been identified as a likely location, however efforts to obtain funding to acquire the property have been unsuccessful.
- In 2012, NCWRC staff assessed the availability of potential habitat on their property at Holly Shelter Gamelands in Pender County, North Carolina. No ponds currently exist that would be suitable for the magnificent ramshorn, and despite initial ideas to create pond habitat that could allow a population to be established in the wild, no appropriate sites appear to be available.

- In 2012-2013, several potentially suitable locations, including a portion of Orton Pond, McKinzie Pond, Pleasant Oaks Pond (Sand Hill Creek Pond), and nearby Pretty Pond, were all brought under single ownership. While access restrictions are still in place, the Service is gaging landowner interest in potentially developing conservation agreements that may eventually allow for re- establishment of snail populations at several locations in the wild.
- The NC Division of Water Resources is working with the city of Wilmington, North Carolina to improve the water quality of Greenfield Lake which formerly supported the species (Greenfield Lake is currently on the states list of impaired water bodies).

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/22/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/22/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/22/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/22/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/22/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/22/2019

SPECIES ACCOUNT: *Pleurocera foremani* (Rough hornsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2010; Southeast Region (R4)

Physical Description

The rough hornsnail's (Pleurocera foremani) shell is elongated, pyramidal, and thick. Growing to about 33 mm (1.3 in) in length, the shell has as many as nine yellowish-brown whorls (Figure 6). The aperture is elongated, angular, channeled at the base, and usually white nacre. The presence of a double row of prominent nodules or tubercles on the lower whorls above the aperture is the most distinctive feature that separates it from other hornsnails (Tryon 1873). These tubercles, along with the size and shape of the shell, distinguish the species from all other pleurocerid snails (Elimia spp., Leptoxis spp., Pleurocera spp.) in the Mobile River Basin. In a hatchery setting, however, the distinctive double row of tubercules do not appear until the second year of life (5-7 mm shell width) (Johnson in litt. 2009) (USFWS, 2014).

Taxonomy

The rough hornsnail is a member of the aquatic snail family of Pleuroceridae. The species was described in 1843 by Lea as Melania foremanii (=foremani) (Tryon 1873). It was later placed in the genus Pleurocera by Tryon (1873), who noted that P. foreman closely resembled species of that genus (USFWS, 2014).

Historical Range

Goodrich (1944) described the historical range as the Coosa River downstream of the Etowah River and at the mouths of a few tributaries. The Etowah River enters the Coosa River in Floyd County, Georgia; however, there are no known museum or site-specific records of the rough hornsnail that validate its range into the state of Georgia (Johnson in litt. 2006a). Historical museum records of the rough hornsnail in the Coosa River (FLMNH in litt. 2006, and elsewhere) indicate that the species occurred in Etowah, St. Clair, Shelby, Talladega, and Elmore Counties, Alabama, a historical range of approximately 322 river km (200 river miles). There are also historical museum records of this species from nine Coosa River tributaries in Alabama, including Big Wills Creek in Etowah County; Kelly, Big Canoe, and Beaver Creeks in St. Clair County; Ohatchee Creek, Calhoun County; Choccolocco and Peckerwood Creeks in Talladega County; Yellowleaf Creek, Shelby County; and Yellow Leaf Creek in Chilton County (FLMNH in litt. 2006) (USFWS, 2014).

Current Range

Lower Yellowleaf Creek in Shelby County, Alabama; and the lower Coosa River below Wetumpka Shoals in Elmore County, Alabama (Figure 8). Lower Walnut Creek in Chilton County, Alabama and lower Hatchet Creek in Coosa County, Alabama (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 rough hornsnail (Pleurocera foremani) (and two other species) under the Endangered Species Act of 1973, as amended (75 FR 67512 - 67550). The critical habitat includes approximately 27.4 kilometers (km) (17 miles (mi)) of stream and river channels as critical habitat for the rough hornsnail in Elmore and Shelby counties in Alabama.

Critical Habitat Designation
Two units are designated as critical habitat for the rough hornsnail (RH 1 and RH 2). These areas include approximately 27.4 kilometers (km) (17 miles (mi)) of stream and river channels in Elmore and Shelby counties, Alabama.Critical habitat includes only the stream channel within the ordinary high water line (75 FR 67512 - 67550).

Unit RH 1: Lower Coosa River, Elmore County, Alabam. Unit 1 for the rough hornsnail includes 21 km (13 mi) of the Lower Coosa River extending from Jordan Dam, downstream to the confluence of the Tallapoosa River in Elmore County, Alabama. The State of Alabama owns navigable stream bottoms within the ordinary high water line, and the Coosa River is considered navigable. The Service believes PCEs 1, 2, 3, and 4 to be suitable throughout the reach, due to the presence of rough hornsnail colonies or other closely related pleurocerid snail species that are known to co-occur with the hornsnail and have similar habitat requirements. Early 1990 records of rough hornsnail from the reach of the Coosa River between Jordan Dam and the Fall Line (FLMNH in litt. 2006), and more recent records of the hornsnail extending 2 km (1.2 mi) below the Fall Line (Hartfield pers. obsv. 2001; Crow in litt. 2008), indicate an occupied range of 14 km (9 mi) in the Lower Coosa River. An additional 7-km (4-mi) channel reach extending downstream to the confluence of the Tallapoosa River is not currently occupied. This downstream unoccupied area is available for natural recolonization, and contains PCEs 1, 2, 3, and 4, including a geomorphically stable channel, and adequate flow, water quality, and substrate, as indicated by the presence of closely related pleurocerids and other mollusk species with similar habitat requirements. Expanding the range of rough hornsnail into the currently unoccupied downstream habitat would reduce the level of stochastic threats to the species, and is essential to its conservation. Threats to the rough hornsnail and its habitat in the Coosa River that may require special management of the PCEs include the potential of 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 hydropower generation, water diversion, or water withdrawal; the potential of significant alteration of water chemistry or water quality due to discharges or land use activities; and 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.

Unit RH 2: Yellowleaf Creek, Shelby County, Alabama. Unit 2 for the rough hornsnail includes approximately 6.4 km (4 mi) of the Yellowleaf Creek channel from the confluence of Morgan Creek, downstream to 1.6 km (1 mi) below the Alabama Highway 25 crossing in Shelby County, Alabama. The State of Alabama owns navigable stream bottoms within the ordinary high water line, and the lower reach of Yellowleaf Creek is considered navigable. The rough hornsnail has been found to occupy this entire reach (Powell in litt. 2009). This reach of Yellowleaf Creek is characterized by a stable channel, natural flows, and appropriate water quality and substrates (PCEs 1, 2, 3, and 4). Threats to the rough hornsnail and its habitat in Yellowleaf Creek that may require special management of PCEs 1, 2, 3, and 4 include the potential of 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 water diversion or water withdrawal; the potential of significant alteration of water chemistry or water quality due to discharges or nonpoint source pollution; and 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.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Elmore and Shelby Counties, Alabama. The primary constituent elements (PCEs) of critical habitat for the rough hornsnail 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, bedrock, or mud substrates with low to moderate amounts of fine sediment and attached filamentous algae.

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 primary constituent elements, such as buildings, bridges, aqueducts, airports, and roads, and the land on which such structures are located.

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 rough hornsnail 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: Unknown

Reproduction Narrative

Adult: Little is known regarding the life history characteristics of this species. Snails in the genus Pleurocera generally lay their eggs in a spiral arrangement on smooth surfaces (Sides 2005), whereas Elimia snails generally lay eggs in short strings (P. Johnson pers. comm. 2006). Although some attempts to induce rough hornsnails to lay eggs in captivity have been unsuccessful (Sides 2005), others have observed females laying eggs individually or in short “strips” (3-10 eggs) during late April into July (Johnson in litt. 2009) (Figure 7). Cultured rough hornsnails have become reproductively active in their 2nd year (Johnson in litt. 2009). Some adult individuals collected from the wild have survived in captivity for 3 years, suggesting a life span of 4 to 5 years in the wild (Garner in litt. 2009, Johnson in litt. 2009) (USFWS, 2014).

Spatial Arrangements of the Population

Adult: Clumped (Inferred from USFWS, 2014)

Environmental Specificity

Adult: Narrow/Specialist (Inferred from USFWS, 2014)

Tolerance Ranges/Thresholds

Adult: Low (Inferred from USFWS, 2014)

Site Fidelity

Adult: High (Inferred from USFWS, 2014)

Habitat Narrative

Adult: Rough hornsnails are primarily found on gravel, cobble, bedrock, and mud in moderate currents. They have been collected at depths of 1 m (3.3 ft) to 3 m (9.8 ft) (Hartfield 2004). The species appears to be very tolerant of silt deposition (USFWS, 2014). High site fidelity, low tolerance ranges/thresholds and Narrow/ specialist environmental specificity are inferred based on strict habitat needs as is clumped spatial arrangement (USFWS, 2014; NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Low (Inferred from USFWS, 2014)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (Inferred from USFWS, 2014)

Dispersal

Adult: Low (Inferred from USFWS, 2014)

Immigration/Emigration

Adult: Low (Inferred from USFWS, 2014)

Dispersal/Migration Narrative

Adult: It is vulnerable to extinction due to limited distribution, declining population trend, limited dispersal and restricted range (Mirarchi et al., 2004) (USFWS, 2014). Mobility, Non-migratory, Dispersal and immigration/emigration are inferred based on taxonomy and habitat (Inferred from USFWS, 2014).

Population Information and Trends

Population Trends:

Unknown

Species Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (inferred from USFWS, 2014)

Representation:

Low (inferred from USFWS, 2014)

Redundancy:

Low (inferred from USFWS, 2014)

Number of Populations:

5 (NatureServe, 2015)

Population Size:

Yellowleaf creek pop. 8 to 32 per sq m; Lower Coosa River one site estimated at 300-400 individuals (USFWS, 2014)

Population Narrative:

At Yellowleaf Creek, it occurs at densities of 8 to 32 per sq. m (USFWS, 2010). In th eLower Coosa River, it is in two discrete areas but no quantitative estimates have been made but at one site, numbers were estimated at 300 to 400 individuals (USFWS, 2010). Until the fall of 2013, the rough hornsnail was only known from two locations: lower Yellowleaf Creek in Shelby County, Alabama; and the lower Coosa River below Wetumpka Shoals in Elmore County, Alabama (Figure 8). However, during the fall of 2013, Mr. Bob Winters (retired-Carnegie Museum of Natural History) reported what appeared to be rough hornsnails from lower Weogufka Creek in Lay Lake. Upon closer examination, Dr. Paul Johnson confirmed that the animals collected by Mr. Winters were in fact rough hornsnails. This new record resulted in the subsequent records of two additional populations (Powell pers. obsv. 2013): lower Walnut Creek in Chilton County, Alabama and lower Hatchet Creek in Coosa County, Alabama. This makes a total of five known populations of the rough hornsnail (USFWS, 2014). Short-term Trend: Decline of >70% NatureServe, 2015). Resiliency, representation and redundancy are inferred based on habitat and taxonomy(inferred from 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:
Protect and manage at least three geographically distinct populations for each species [To achieve this criterion, the populations can include the Oostanaula for the interrupted rocksnail and Yellowleaf Creek and Lower Coosa River for the rough hornsnail] (USFWS, 2014).

Achieve demonstrated and sustainable natural reproduction and recruitment in each population for each species as evident by multiple age classes of individuals, including naturally recruited juveniles, and recruitment rates exceeding mortality rates for a period of five years (USFWS, 2014).

Develop and implement habitat and population monitoring programs for each population (USFWS, 2014).

Delisting Criteria:
The present or threatened destruction, modification, or curtailment of its habitat or range (USFWS, 2014).

Disease or predation (USFWS, 2014)

The inadequacy of existing regulatory mechanisms (USFWS, 2014)

Other natural or manmade factors affecting its continued existence (USFWS, 2014)

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 (USFWS, 2014).

References

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SPECIES ACCOUNT: *Polygyriscus virginianus* (Virginia fringed mountain snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; Northeast Region (R5) (USFWS, 2015)

Physical Description

The shell is a pale greenish color and has four promient raised spiral lines with less prominent spiral lines between them. The shell is 0.18 inches in diameter and 0.06 inches in height. The animal inside, is white and probably blind (USFWS, 2015).

Taxonomy

Burch (1947) first described this snail as Polygyra virginiana (Polygridae) and contrasted it with Polygyra cereolus carpenteriana. Pilsbry (1948) examined the species and felt that it was not a Polygyra and established a new subgenus Polygyriscus still within the family Polygyridae. Later Burch (1962) treated this as a full genus, making it a monotypic genus. Taxonomic affinities within snails are determined by soft body parts and internal anatomy (Batie 1987). Until 1971, when three specimens were sent to the Chicago Field Museum, all taxonomic classification had been based on shell characteristics. Solem (1975), who examined these specimens and was able to look at the internal body parts and radular teeth, placed the snail in the family Helicodiscidae (USFWS, 2007).

Current Range

From only a 9.9 km region along the bluffs of the New River in Pulaski county, Virginia (Batie, 1987a; 1987b; 1987c).

Critical Habitat Designated

No;

Life History

Reproduction Narrative

Adult: Almost nothing is known regarding the reproduction of P. virginianus. Reproduction may be similar to that of Helicodiscus parallelus which lays 1-2 eggs per clutch (USFWS, 1983).

Geographic or Habitat Restraints or Barriers

Adult: Up to 1,800 ft. elevation (USFWS, 1983; NatureServe, 2015)

Environmental Specificity

Adult: Very narrow (Natureserve, 2015)

Habitat Narrative

Adult: Burrowing calcifile (10 to 45 cm deep) that is not found in leaf litter but burrows in loose, damp, dolomitic limestone talus mixed with rootlets and clay (Batie, 1987a; 1987b; 1987c). Look for loose talus at the base of high bluffs, talus heavily shaded by overhanging tree canopy, talus surface partially or completely covered by honeysuckle vines, and talus rocks which are permanently moist. It can live up to 2 m beneath the surface of talus slope at an elevation of 1800 feet; and needs a place with moist, loosely compacted soil with high calcium content and moderate temperature (USFWS, 1983; NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigrant (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: No (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Nonmigrant (NatureServe, 2015). Species is only known from one small location (NatureServe, 2015)

Population Information and Trends

Population Trends:

Unclear if species is extant (USFWS, 2007)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Extremely restricted range and no new records to the point where the species might be extinct (more surveys are necessary). Insufficient genetic samples are available to analyze genetic trends, but it can be assumed that genetic variability is low with such small population size in such a limited area (USFWS, 2008). The scarcity of live individuals over the last 60 years has made it impossible to project abundance or trends (USFWS, 2008). Unknown Live specimens (12) were first collected in 1947 with 2 additional specimens the following year; but it wasn't until 25 years later that additional live specimens were collected (3 in 1981, 1 in 1986) and living juveniles have not been seen since 1971 (Batie, 1987a; 1987b; 1987c). Hubricht (1982) cites only from the New River bluff, opposite Radford, Montgomery Co., Virginia. 146 documented specimens collected 1937 to 1986 with only 27 living (Batie, 1987a; 1987b; 1987c). Living snails only within a 70 m long stretch along the river bluffs (New River), opposite Redford, Montgomery Co., Virginia (Batie, 1987a; 1987b; 1987c) (NatureServe, 2015)

Threats and Stressors

Stressor: Small population size? (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: If the snail is found to be extant, it is possible that small-population effects may limit its continued survival and/or recovery potential. Uncertainties surrounding its current population status and distribution may pose the greatest threat to the species due to the potential for inadvertent loss of individuals or populations stemming from human activities and/or natural events (USFWS, 2007).

Recovery

Delisting Criteria:
All habitat where the species occurs is assured long-term protection from adverse impacts (USFWS, 2007).

A long-term land management and monitoring program is established throughout the species range (USFWS, 2007).

The monitoirng program indicates no downward trend in the species distribution or habitat quality (USFWS, 2007).

Conservation Measures and Best Management Practices:

- Conduct a comprehensive survey to determine a. if the species ie extant and, if so, its population status; and b. if the habitat is associated with shells and live specimens observed to date is the preferred habitat type (USFWS, 2007).
- Determine land ownership of sites, and implement some degree of long-term protection (USFWS, 2007).

References

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SPECIES ACCOUNT: *Pseudotryonia adamantina* (Diamond Tryonia)

Species Taxonomic and Listing Information

Listing Status: Endangered; 07/09/2013; Southwest Region (R2) (USFWS, 2016)

Physical Description

Thermal spring snail of the family Hydrobiidae known from a spring and seeps in the Pecos River Valley near Fort Stockton, Texas. See Taylor (1987) for a morphological description. Shell small- to medium-sized, conical. Penial ornament of 1 distal papilla on inner edge and 1 medial papilla on outer edge (Hershler, 2001). Diamond Y Spring snail is a very small snail, measuring only 2.9 to 3.6 millimeters (.11 to .14 inches) in length. The shell is narrowly conical, with obtuse apex and broadly rounded anterior end (Taylor 1987). Whorls 4.75 to 5.75 in larger females, regularly convex and swollen to weakly shouldered, separated by a deeply incised suture (Taylor 1987). (NatureServe, 2015)

Taxonomy

The Diamond tryonia was first described by Taylor (1987, p. 41) as Tryonia adamantina. atic studies (Hershler et al. 1999, p. 377; Hershler 2001, pp. 7, 16) of these snails have been conducted using mitochondrial DNA sequences and morphological characters. These analyses resulted in the Diamond tryonia being reclassified into the new genus Pseudotryonia (Hershler 2001, p. 16). Based on these published studies, we conclude that Diamond tryonia meets the definition of a species under the Act (USFWS, 2013).

Historical Range

See current range. The historic distribution may have been larger than the present distribution (USFWS, 2013).

Current Range

This species is endemic to less than 2 km of stream in the Diamond Y Spring system and associated outflows in Pecos River Valley (Pecos River basin) near Fort Stockton, Pecos Co., Texas (Taylor, 1987; Hershler, 2001; USFWS, 2003).

Critical Habitat Designated

Yes; 7/9/2013.

Legal Description

On July 9, 2013, the U.S. Fish and Wildlife Service designated critical habitat for Diamond tryonia (Pseudotryonia adamantina) under the Endangered Species Act of 1973, as amended (78 FR 40970 - 40996). The critical habitat designation includes 1 critical habitat unit, which encompasses 178.6 acres (441.4 hectares) in Pecos County, Texas. This unit was occupied at the time of designation (USFWS, 2013).

Critical Habitat Designation

The Diamond Y Spring System is designated as critical habitat for the Diamond tryonia.

Diamond Y Spring Unit. Diamond Y Spring Unit consists of 178.6 ha (441.4 ac) that is currently occupied by the Diamond tryonia and contains all of the features essential to the conservation of the species. Diamond Y Spring and surrounding lands are owned and managed by The Nature Conservancy. The final designation includes the Diamond Y Spring and approximately 6.8 km (4.2 mi) of its outflow, including both upper and lower watercourses, ending at approximately 0.8 km (0.5 mi) downstream of the State Highway 18 bridge crossing. Also included in this unit is approximately 0.8 km (0.5 mi) of Leon Creek upstream of the confluence with Diamond Y Draw. The boundaries of this unit extend out laterally beyond the mapped spring outflow channels to incorporate any and all small springs and seeps that may not be mapped or surveyed but are expected to contain the species and the necessary physical or biological features. The unit contains all of the identified physical or biological features. Habitat in this unit is threatened by declining spring flows due to drought or groundwater withdrawals, subsurface drilling and other oil and gas activities that could contaminate surface drainage or aquifer water, the presence of nonnative snails and feral hogs, the introduction of other nonnative species, and modification of spring outflow channels. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Primary Constituent Elements/Physical or Biological Features

A critical habitat unit is designated for Pecos County, Texas. Within this area, the primary constituent elements of the physical or biological features essential to the conservation of Diamond tryonia are springs and spring-fed aquatic systems that contain:

(i) Permanent, flowing, unpolluted water (free from contamination) emerging from the ground and flowing on the surface;

(ii) Water temperatures that vary between 11 and 27 °C (52 to 81 °F) with natural seasonal and diurnal variations slightly above and below that range;

(iii) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for breeding, egg laying, maturing, feeding, and escape from predators;

(iv) Abundant food, consisting of algae, bacteria, decaying organic material, and submergent vegetation that contributes the necessary nutrients, detritus, and bacteria on which these species forage; and

(v) Either an absence of nonnative predators and competitors or nonnative predators and competitors at low population levels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, roads, oil and gas well pads, and other paved areas) and the land on which they are located existing within the legal boundaries on August 8, 2013.

The features essential to the conservation of the Diamond tryonia may require special management considerations or protection to reduce threats, such as reducing or eliminating water in suitable or occupied habitat through drought or groundwater pumping; introducing pollutants to levels unsuitable for the species; and introducing nonnative species into the inhabited spring systems such that suitable habitat is reduced or eliminated. Management activities that could ameliorate these threats include management of groundwater levels to ensure the springs remain flowing (all spring sites), managing oil and gas activities to eliminate the threat of groundwater or surface water contamination (Diamond Y Spring), maintaining the pump within Phantom Lake Spring to ensure consistent flow, managing existing nonnative species, red-rim melania, quilted melania, and feral hogs (San Solomon, Giffin, Phantom Lake, and Diamond Y Springs), and preventing the introduction of additional nonnative species (all spring sites).

Life History

Feeding Narrative

Adult: All of these snails are presumably fine-particle feeders on detritus (organic material from decomposing organisms) and periphyton (mixture of algae and other microbes attached to submerged surfaces) associated with the substrates (mud, rocks, and vegetation) (Allan 1995, p. 83; Hershler and Sada 2002, p. 256; Lysne et al. 2007, p. 649). Dundee and Dundee (1969, p. 207) found diatoms (a group of single-celled algae) to be the primary component in the digestive tract, indicating they are a primary food source (USFWS, 2013).

Reproduction Narrative

Adult: The lifespan of most aquatic snails is thought to be 9 to 15 months (Taylor 1985, p. 16; Pennak 1989, p. 552) (USFWS, 2013). These type of snails (snails in the former family Hydrobiidae) typically reproduce several times during the spring to fall breeding season (Brown 1991, p. 292) and are sexually dimorphic (males and females are shaped differently), with females being characteristically larger and longer-lived than males (USFWS, 2013).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Habitat for this species is mud substrates on the margins of small springs, seeps, and marshes in flowing water associated with cattail and sedge wetlands (but not marshy pools) (Taylor, 1987). The species occurs in the same system with Tryonia circumstriata (= Tryonia stocktonensis), but they are mutually exclusive; and co-occurs with Assiminea pecos, Physa mexicana, Stagnicola caperata, Ferrissia californica (= Ferrissia rivularis), Laevapex fuscus, and Pisidium casertanum (Taylor, 1987; USFWS, 2003). Benthic (NatureServe, 2015). High ecological integrity of the population and site fidelity as well as low tolerance ranges are inferred based on species extremely restricted range and habitat requirements.

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 2013)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2013)

Dispersal

Adult: Low (USFWS, 2013)

Immigration/Emigration

Adult: Unlikely (USFWS, 2013)

Dispersal/Migration Narrative

Adult: Because of their small size and dependence on water, significant dispersal (in other words, movement between spring systems) does not likely occur, although on rare occasions aquatic snails have been transported by becoming attached to the feathers and feet of migratory birds (Roscoe 1955, p. 66; Dundee et al. 1967, pp. 89–90). In general, the species have little capacity to move beyond their isolated aquatic environments (USFWS, 2013).

Population Information and Trends

Population Trends:

Unknown (NatureServe, 2015)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

250 - 10,000 individuals (NatureServe, 2015)

Population Narrative:

These snails likely have life spans of 9-15 months and reproduce several times during the spring to fall breeding season (Taylor, 1987). This species is extremely restricted and somewhat declining in unusual human created habitat so virtually no opportunity for natural dispersal without human intervention is possible (USFWS, 2003). There is no available information that the species' early historic distribution was larger than the present distribution. However, other area springs may have contained the same species, but because these springs have been dry for many decades, there is no opportunity to determine the potential historic occurrence of the snail fauna (USFWS, 2003). Unknown A healthy population (formerly estimated in the thousands but currently still healthy with lower densities) exists in a small area of Phantom Lake Spring, Phantom Cave, Texas (Dundee and Dundee, 1969; Taylor, 1987; Landye in litt. cited in USFWS, 2003), despite massive habitat alteration in the area. Similar habitat alteration occurred in San Solomon Spring in Balmorea State Park, but no recent population estimates are available, but historic population estimates place this population in the thousands. A newly discovered population in East Sandia Spring in Balmorea State Park with healthy population numbers (perhaps thousands) (USFWS, 2003). This species occurs only in the drainage of Toyah Creek, Pecos River basin, Texas (Hershler, 2001) in three spring systems (Phantom Lake, San Solomon Spring, and East Sandia Spring). Included in Toyah Creek tributaries are East Sandia Springs just east of Balmorhea in Reeves County, a small area of Phantom Lake Spring, Phantom Cave (Dundee and Dundee, 1969; Taylor, 1987) and San Solomon Spring in Balmorea State Park, Texas. (Taylor, 1987). Today the snails are limited to low densities in the small pool at the mouth of Phantom Cave and can not be found in the irrigation canal downstream (USFWS, 2003). In the summer of 2000, East Sandia Spring was surveyed for aquatic macroinvertebrates for the first time. A healthy abundance and diversity of springsnails (including what appears to be Phantom springsnail) were present in the small stream that makes up the spring outflow. The entire habitat is less than 150 meters in length (USFWS, 2003). (NatureServe, 2015). Low resiliency, representation and redundancy are based on the low number of known populations and the extremely restricted range this species inhabits.

Threats and Stressors

Stressor: Groundwater level decline (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The primary threat to the continued existence of the San Solomon Spring species is the degradation and potential future loss of aquatic habitat (flowing water from the spring outlets) due to the decline of groundwater levels in the aquifers that support spring surface flows. Habitat for these species is exclusively aquatic and completely dependent on spring flows emerging to the surface from underground aquifer sources. Spring flows throughout the San Solomon Spring system have and continue to decline in flow rate, and as spring flow declines, available aquatic habitat is reduced and altered. If one spring ceases to flow continually, all habitats for the Phantom springsnail, Phantom tryonia, and diminutive amphipod are lost, and the populations will be extirpated. If all of the springs lose consistent surface flows, all natural habitats for these aquatic invertebrates will be gone, and the species will become extinct.

Recovery

Recovery Actions:

- No recovery plan has been written for this species.

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Determination of Endangered Species Status for Six West Texas Aquatic Invertebrates.

SPECIES ACCOUNT: *Pyrgulopsis (=Marstonia) pachyta* (Armored snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 2/25/2000; Southeast Region (R4) (USFWS, 2016)

Physical Description

The armored snail is a small hydrobiid snail (usually less than 4 mm in length) (Thompson 1977 and Garner 2004a). It is distinguished from other closely related species by the characteristics of both its verge (male reproductive organ) and shell. The armored snail has a small raised gland on the ventral surface of the verge (a trait common only with the beaverpond snail (P. castor) of this genus) and two small glands along the left margin of the apical (tip) lobe. The apical lobe is smaller than in most species of Pyrgulopsis (Thompson 1977). Garner (1993) noted some variation in verge characteristics (more developed apical lobes), but attributed the differences to temporal changes in verge morphology throughout the annual life cycle. The shell is easily identified by its ovate-conical shape, its pronounced thickness, and its complete peristome (edge of the opening). Other Pyrgulopsis species with ovate-conical shells have much thinner, almost transparent shells, and the peristome is seldom complete across the parietal margin (area along the opening abutting the main body of the shell) of the aperture (opening) (Thompson 1977) (USFWS, 2009).

Taxonomy

The armored snail is a small snail of the family Hydrobiidae (USFWS, 2010).

Historical Range

The armored snail is currently only known from Limestone and Piney Creeks, Limestone County, Alabama (Figure 1), and appears to be most abundant in submerged root masses and bryophytes (non-vascular land plants, e.g. mosses) along the creek edges, but also may occur on rocks and leafy/woody debris, and on other aquatic macrophytes (aquatic plants) (Garner 2004a, Haggerty and Garner 2007, 2008) (USFWS, 2009).

Current Range

Within Limestone Creek, the snail occurs within the lower 21 unimpounded kilometers (13 miles) (Figure 1), in total Limestone Creek is approximately 72 kilometers (44.7 miles long). Within Piney Creek, the armored snail is known to inhabit the lower 13 kilometers (8 miles) (Figure 1) of Piney Creek’s 62 total kilometers (38.5 miles) (Garner 2004a, Haggerty and Garner 2007). While the snail remains viable in both Limestone and Piney Creeks, they appear to be more widely dispersed in Limestone Creek (Haggerty and Garner 2008) (USFWS, 2009).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Periphyton inferred because sedimentation is noted as a possible threat to periphyton food sources. Detritis inferred because most aquatic snails feed on detritus (USFWS, 2009; NatureServe, 2015)

Reproduction Narrative

Adult: Reproductive information is not available. The armored snail is assumed to be an annual species like other similar hydrobiid species (P.D. Johnson, Alabama Department of Conservation and Natural Resources (ADCNR), pers. comm., 2008) (USFWS, 2009; NatureServe, 2015).

Spatial Arrangements of the Population

Adult: Clumped distribution (inferred from USFWS, 2009; NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2009; NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (see threats) (inferred from USFWS, 2009; NatureServe, 2015)

Habitat Narrative

Adult: The armored snail is found and appears to be most common in submerged roots, leaves, and bryophytes along the edges, submerged bryophytes growing on rocks in moderate current, and in water willow. They are also found in areas of slow to moderate flow in the submerged detritus, leaves, and tree rootlets along pool edges (Thompson 1974, FWS 1994, Haggerty and Garner 2007, 2008) (inferred from USFWS, 2009; NatureServe, 2015)

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015).

Resiliency:

Low (inferred from NatureServe, 2015 and USFWS, 2010)).

Representation:

Low (inferred from NatureServe, 2015 and USFWS, 2010))

Redundancy:

Low (inferred from NatureServe, 2015 and USFWS, 2010))

Population Growth Rate:

Decreasing (inferred from NatureServe, 2015 and USFWS, 2010))

Number of Populations:

Two (NatureServe, 2015).

Population Narrative:

Known from a few sites along two short river reaches of Piney and Limestone Creeks (Mirarchi et al., 2004) only in 2 very short stretches and the two populations are probably remnants of one larger population now separated by Wheeler Lake (USFWS, 2000) (USFWS, 2010). The short term Trend indicates a decline of 10-30% (NatureServe, 2015).

Threats and Stressors

Stressor: Habitat modification and degradation (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Human-related activities and development within the basin has continued to strain the snail's habitat and resources. Some of the threats include: habitat modification from increased development (commercial and residential), indiscriminate logging, agriculture (row crops and livestock), withdrawal of water, road and bridge construction, open cut trenching, and various other point and nonpoint pollution discharges. These impacts continue to increase as human activities expand outward from the cities of Huntsville, Madison, Decatur, and Athens into the Limestone and Piney Creek watersheds.

Stressor: Sediment accumulation (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Sediment accumulation and changes in flow and water chemistry in impounded stream and river reaches reduce food and oxygen availability and eliminate essential breeding habitat for riverine snails (USFWS, 2010).

Stressor: Chemical spills (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Toxic chemicals spills due to the numerous road crossings are not a significant threat to the snails but are considered a potential threat (USFWS, 2010).

Stressor: Point and Non-point pollution (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Water quality degradation from both point and nonpoint sources currently affect these species. Stream discharges from these sources may result in eutrophication (nutrient enrichment), decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry. Nutrients, usually phosphorus and nitrogen, may emanate from agricultural field, residential lawns, livestock operations, and leaking septic tanks at levels that result in eutrophication and reduced oxygen levels in small streams (USFWS, 2010).

Stressor: Chip mills (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Chip mills have the potential to harvest a larger area of land as compared to typical logging operations. However, if areas harvested for chip mills observe best management practices, it is unlikely they will have any more effect than other land-clearing activities (USFWS, 2010).

Recovery

Reclassification Criteria:
No Recovery Plan Available

Recovery Actions:
- No Recovery Plan Available

Conservation Measures and Best Management Practices:
- Develop a contingency plan for response to a spill or natural disaster within occupied snail habitat (USFWS, 2010).
- Conduct quantitative surveys within known habitats; survey the tributaries of both Limestone and Piney creeks for occurrences, and survey additional creeks within northern Alabama for additional populations (USFWS, 2010).
- Develop partnerships and utilize conservation initiatives with landowners along the riparian habitats and within the recharge zone of the Limestone and/or Piney Creek basins (USFWS, 2010).
- Conduct genetic work to draw comparisons between closely related species within the known range of the armored snail, and examine the genetics of the Marstonia species within the adjacent Beaverdam Creek (USFWS, 2010).
- Provide public outreach and education in regards to the armored snail to property owners and farmers along the creeks (USFWS, 2010).
- Pursue opportunities including land acquisition, conservation easements, etc. to secure creek habitat (USFWS, 2010).
- Conduct a detailed analysis of habitat requirements, including physicochemical parameters of the stream and more specific measurements of the microhabitat used by the snail (USFWS, 2010).
- Develop propagation techniques (USFWS, 2010).
- Conduct life history studies (USFWS, 2010).

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SPECIES ACCOUNT: *Pyrgulopsis bernardina* (San Bernardino springsnail)

Species Taxonomic and Listing Information

Listing Status: Threatened; April 17, 2012 (77 FR 23060).

Physical Description

The San Bernardino springsnail has a narrow, conic shell and is 1.3 to 1.7 millimeters (0.051 to 0.067 inch) in height. The shell has 3.25 to 4.0 whorls, an ovale operculum, and is light amber in color. Females are typically larger than males (USFWS 2012).

Taxonomy

The San Bernardino springsnail was originally described as Yaquicoccus bernardinus and then as Pyrgulopsis. The species was renamed Pyrgulopsis in 1994, and this is recognized to be a valid taxon by the U.S. Fish and Wildlife Service. The San Bernardino springsnail is one of 170 known species of the family Hydrobiidae found in the United States. The characteristic that differentiates Pyrgulopsis from other springsnail species is the male genitalia. The San Bernardino springsnail's distinctive penis is medium-sized, with filament shorter than base, tapering, and lobe absent. This species is distinguished from other forms by its smaller ventral gland (sexual organ) and continuous transition between penis base and filament (77 FR 23060; ECOS 2015; USFWS 2015).

Historical Range

The historic range of the San Bernardino springsnail in the United States was limited to Cochise County, in southern Arizona. The San Bernardino springsnail could be found along the Rio San Bernardino and the headwaters of the Rio Yaqui in Cochise County, specifically in springs in the San Bernardino National Wildlife Refuge (NWR) and on John Slaughter Ranch Museum private property: Snail Spring, Horse Spring, Goat Tank Spring, and Tule Spring. In Mexico, the San Bernardino springsnail occurred throughout different springs in Sonora and in the San Bernardino and Cajon basins (77 FR 23060; USFWS 2012).

Current Range

The current range of the species in the United States is now believed to be limited to Goat Tank and Horse Springs on John Slaughter Ranch Museum private property in southern Arizona. According to recent genetic studies, the San Bernardino springsnail also occurs in Mexico at five sites in Sonora and in at least nine different springs in the San Bernardino and Cajon Bonito Basins, with a total area of occupancy of 2.14 hectares (ha) (5.3 acres [ac.]) (77 FR 23060; NatureServe 2015; USFWS 2012).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 4/17/2012.

Legal Description

On April 17, 2012, the U.S. Fish and Wildlife Service designated critical habitat for Pyrgulopsis bernardina. Approximately 2.0 acres (0.8 hectares) are designated as critical habitat for San Bernardino springsnail in Cochise County, Arizona.

Critical Habitat Designation

Critical habitat for the San Bernardino springsnail is designated in two springs currently occupied and two springs not currently occupied by the species.

Snail Spring Unit. The Snail Spring Unit encompasses 1.129 ac (0.457 ha) in Cochise County, Arizona. The entire unit is owned by the State of Arizona and managed by the John Slaughter Ranch Museum. The spring is approximately 16 ft (5 m) in diameter, and has a spring run that goes south from the spring approximately 77 ft (23 m) to a manmade ditch, which runs 34 ft (10 m) to a dirt road. It passes under the road in a 12-ft (4-m) culvert, then flows approximately 56 ft (17 m) below the road. The Service is not designating the road as critical habitat, but is designating the culvert beneath the road, because it contains flowing water that provides PCE 1. The spring and spring run down to the ditch are dry and unoccupied, though they contain PCE 3, substrate. The ditch is unoccupied, though all the PCEs are present. Included as part of this critical habitat designation is a 3.3-ft (1-m) upland area on each side of the spring, spring run and ditch, because moist soils and upland vegetation are necessary to produce food for the snails and protect the substrate they use. Because of the small size of the spring, spring run, and ditch, the Service is precluded from mapping them precisely due to inaccuracies inherent in the use of satellites for locating and mapping. Therefore, for mapping purposes the Service created a circle that encompasses them. The critical habitat is the spring, spring run, ditch and buffer within the 249-ft (76-m) diameter circle centered on UTM coordinate 663858, 3468182 in Zone 12. The Snail Spring Unit is currently unoccupied by the San Bernardino springsnail, but it was historically occupied. This Snail Spring Unit is essential for the conservation of the species, because it will provide population redundancy following future reintroduction of the species.

Goat Tank Spring Unit. This unit encompasses 0.005 ac (0.002 ha) in Cochise County, Arizona. The entire unit is in State ownership and managed by the John Slaughter Ranch Museum. The spring is contained within a square concrete box approximately 2 ft by 3 ft (0.6 m by 0.9 m). There is also some spring seepage emanating from the base of a cottonwood tree about 6.6 ft (2 m) from the spring-box. The Service designated as critical habitat a 3.3-ft (1-m) upland area on each side of the springbox and spring seepage, because it has moist soils and vegetation that produces food for the snails and protects the substrate the snails use. Because of the small size of the spring-box and spring seepage, we are precluded from mapping them precisely due to inaccuracies inherent in the use of satellites for locating and mapping. Therefore, for mapping purposes the Service created a circle that encompasses them. The critical habitat designation is the spring-box, spring seepage, and buffer within the 16-ft (5-m) diameter circle centered on UTM coordinate 663725, 3468162 in Zone 12. This unit is occupied at the time of this final listing rule, and contains all the PBFs essential for the conservation of the species. The PBFs which may require special management are freeflowing springs and habitat free of disturbance from nonnative competitors. Threats to the San Bernardino springsnail in this unit that may require special management include water depletion and drought. Water depletion has affected the species with a loss of flowing water at nearby Snail Spring in the recent past (Cox et al. 2007, p. 2; Smith et al. 2003, p. 1; Malcom et al. 2003, p. 18). Also, potential threats may be posed by nonnative snails, should they be introduced, and by fire retardant chemicals, should they be applied in other portions of the San Bernardino Valley and carried into this unit by wind drift.

Horse Spring Unit. This unit encompasses 0.078 ac (0.032 ha) in Cochise County, Arizona. The entire unit is State-owned and managed by the John Slaughter Ranch Museum. The spring emerges from a PVC pipe, which is enclosed in a spring-box, and water flows out in a spring-run that is approximately 1.6 ft (0.5 m) wide and 51 ft (16 m) in length. The Service designated as critical habitat a 3.3-ft (1-m) buffer of upland area on each side of the springhead and spring-run, because it has moist soils and vegetation that produce food for the snails and protect the substrate they use. Because of the small size of the springhead and spring-run, the Service is precluded from mapping them precisely due to inaccuracies inherent in the use of satellites for locating and mapping. Therefore, for mapping purposes the Service created a circle that encompasses them. The designated critical habitat is the spring-box, spring seepage, and buffer within the 66 ft (20 m) diameter circle centered on UTM coordinate 663772, 3468091 in Zone 12. The Horse Spring Unit is occupied at the time of this listing, and contains all the PBFs essential for the conservation of the species. The PBFs which may require special management are free-flowing springs and habitat free of disturbance from nonnative competitors. Threats to the San Bernardino springsnail in this unit that may require special management include groundwater depletion and drought. Groundwater depletion has affected the species with a loss of flowing water at nearby Snail Spring in the recent past (Cox et al. 2007, p. 2; Smith et al. 2003; p. 1, Malcom et al. 2003, p. 18), and may threaten this site in the future. Also, potential threats may be posed by nonnative snails, should they be introduced, and by fire retardant chemicals, should they be applied in other portions of the San Bernardino Valley and carried into this unit by wind drift.

Tule Spring Unit. This unit encompasses 0.801 ac (0.324 ha) in Cochise County, Arizona. The entire unit is in Federal ownership and managed by the San Bernardino NWR. The spring forms a pond approximately 75 ft (23 m) north-south and 43 ft (13 m) east-west, and it has a spring-run that is approximately 71 ft (22 m) in length. The spring run emerges from the southeastern side of the spring pond, runs northeast for approximately 41 ft (13 m) to a manmade ditch, which runs southeast 30 ft (9 m). The Service designated as critical habitat a 3.3-ft (1-m) buffer of upland area on each side of the spring, spring-run, and ditch, because it has moist soils and vegetation that produce food for the snails and protect the substrate they use. Although there is a pond at this location, the seeps where the water emerges are not located within the pond. The pond is included in the designation, because, along with the spring, seeps, spring run, ditch, and upland buffer, it comprises an interrelated, functioning aquatic system important for the springsnails and the fish. The water from the pond will maintain a springbrook, and the springbrook will drain into other ponds. Because of the small size of the spring, spring-run, and ditch, the Service is precluded from mapping them precisely due to inaccuracies inherent in the use of satellites for locating and mapping. Therefore, for mapping purposes the Service created a circle that encompasses them. The critical habitat is the spring, springrun, ditch and buffer within the 210-ft (64-m) diameter circle centered on UTM coordinate 664259, 3468499 in Zone 12. The Tule Spring Unit is currently unoccupied by the San Bernardino springsnail at the time of this listing, but is considered to have been historically occupied (Malcom et al. 2003, p. 19), and shares a common aquifer and similarities in water chemistry, temperature, and hydrology with Snail Spring. We consider the Tule Spring Unit to be essential to the conservation of the species, because it contains all the PCEs necessary for the life-history processes, and it provides population redundancy following future reintroduction of the species. Threats to the San Bernardino springsnail in this unit include the potential use of fire retardant chemicals, water depletion, drought, and the potential introduction of nonnative snails.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Cochise County, Arizona. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the San Bernardino springsnail consist of four components:

(i) Adequately clean spring water (free from contamination) emerging from the ground and flowing on the surface;

(ii) Periphyton (attached algae), bacteria, and decaying organic material for food;

(iii) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for egg laying, maturing, feeding, and escape from predators; and

(iv) Either an absence of nonnative predators (crayfish) and competitors (snails) or their presence at low population levels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures other than the road culvert and concrete spring-boxes, which are included to protect the water flowing within them.

The features essential to the conservation of the San Bernardino springsnail may require special management considerations or protections to reduce the following threats: Soil erosion following high-intensity wildfires, exposure to fire retardant, springhead inundation, water depletion and diversion, and the introduction of nonnative predators and competitors. Management activities that could ameliorate threats include (but are not limited to) protecting against: (1) Wildfire and fire retardant used to fight wildfires, (2) predation by nonnative crayfish, (3) water depletion and diversion, (4) potential competition from nonnative New Zealand mudsnails or predation by nonnative crayfish, and (5) harm from livestock and other ungulates through fencing to protect spring habitats from damage. Special management is also needed for the purposes of adaptive management, and includes continuing to conduct research on the springsnails, and on critical aspects of their biology (for example, reproduction, sources of mortality, sensitivity to contaminants, dispersal behavior, anti-predator behavior, etc.).

Life History

Feeding Narrative

Adult: The San Bernardino springsnail (Pyrgulopsis bernardina) is a detritivore and a benthic grazer. The diet of the San Bernardino springsnail is widely distributed and consists of periphyton, or algae, detritus, bacteria, and other microbes that live in aquatic environments. San Bernardino springsnails graze and eat off of firm substrates such as cobble, gravel, or woody debris. Currently, the San Bernardino springsnail has no competitors for food resources, although the threat exists that invasive species such as the New Zealand mudsnail (Potamopyrgus antipodarum) may compete for food resources in the future (USFWS 2012).

Reproduction Narrative

Adult: Springsnails in the genus Pyrgulopsis are egg-layers, with a single small egg capsule deposited on a firm substrate. A firm substrate such as cobble, gravel, or woody debris is essential for egg laying. The San Bernardino springsnail has a low parental investment in the eggs, and the larval stage of the San Bernardino springsnail is completed in the egg capsule. Upon hatching, tiny snails emerge into their adult habitat. San Bernardino springsnails live an average of 9 to 15 months (77 FR 23060; NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Water diversion and habitat destruction limit the geographic range of the San Bernardino springsnail. San Bernardino springsnails are also found in higher density closer to springheads; populations are not found in soft substrates and instead have an abundance in coarse, firm substrates (77 FR 23060).

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow

Tolerance Ranges/Thresholds

Adult: Low; San Bernardino springsnails are sensitive to water quality, and are usually found within relatively narrow habitat parameters (77 FR 23060).

Site Fidelity

Adult: Moderate

Habitat Narrative

Adult: San Bernardino springsnails are clumped in freshwater rheocrene (emerging from the ground as a flowing stream) springs, seeps, spring pools, outflows, and diverse flowing waters at elevations around 1,160 m (3,800 ft.), and are rarely found in mud or soft sediments. San Bernardino springsnails need close proximity to springheads where water emerges from the ground. Springheads play a key role in the life history of springsnails; San Bernardino springsnails have a decreased abundance farther away from spring vents, because they need a habitat with the stable water chemistry and flow provided by spring waters. The San Bernardino springsnail are habitat specialists, are found within relatively narrow habitat parameters, and are sensitive to degraded water quality. San Bernardino springsnails are associated with waters having cobble substrates; high vegetation density; dissolved oxygen; water temperature ranging from 14 to 22 degrees Celsius (57 to 72 degrees Fahrenheit); and pH values between 7.6 and 8.0. Dissolved salts such as calcium carbonate are also important factors for the San Bernardino springsnail, because they are essential for shell formation. (77 FR 23060; NatureServe 2015; USFWS 2012).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: San Bernardino springsnails have been known to disperse by becoming attached to the feathers of migratory birds (77 FR 23060).

Immigration/Emigration

Adult: Unlikely

Dependency on Other Individuals or Species for Dispersal

Adult: Migratory birds (see dispersal).

Dispersal/Migration Narrative

Adult: The San Bernardino springsnail is nonmigratory, with limited and low mobility. They are unlikely to immigrate or emigrate. San Bernardino springsnails have been known to disperse by attaching themselves to the feathers of migratory birds (77 FR 23060; NatureServe 2015).

Population Information and Trends

Population Trends:

Short-term trend decreasing 30 to 50 percent; long-term trend decreasing 70 to 90 percent (NatureServe 2015).

Species Trends:

Decreasing

Resiliency:

Moderate

Representation:

Low

Redundancy:

Low

Population Growth Rate:

Declining

Number of Populations:

1 to 5; distribution of San Bernardino springsnail in the United States is limited to one natural spring on a private ranch, and to an artificial spring habitat on the San Bernardino NWR, in Cochise County, Arizona (NatureServe 2015).

Population Size:

100,000 to 1,000,000 individuals. The density of San Bernardino springsnail is highly variable; the mean density is 55,929 per square m (602,015 per sq. ft.) (NatureServe 2015).

Adaptability:

Low

Additional Population-level Information:

Limited information is available on population sizes for the San Bernardino springsnail (77 FR 23060). The single known natural site in the United States (Arizona) is currently considered viable, but the population on the artificial stream in San Bernardino NWR, although still extant, is represented by few individuals. One of two sites in Sonora, Mexico, a 50-ac. ciénega just across the border, is believed to be doing well (NatureServe 2015).

Population Narrative:

The San Bernardino springsnail has a population of between 100,000 and 1,000,000 individuals. The population is on decline, and the short-term trend is decreasing 30 to 50 percent; and the long-term trend is decreasing 70 to 90 percent. San Bernardino springsnails have low adaptability, redundancy, and representation rates, and a moderate resiliency rate . There are one to five populations, but the distribution of the San Bernardino springsnail in the United States is limited to one natural spring on a private ranch and in an artificial spring habitat on the San Bernardino NWR, in Cochise County, Arizona. The location on the private ranch in the United States is currently considered viable, but the population on the artificial stream in San Bernardino NWR, although extant, is represented by few individuals. One of two sites in Sonora, Mexico, a 50-ac. ciénega just across the border, is believed to be doing well (NatureServe 2015).

Threats and Stressors

Stressor: Springhead Inundation
Exposure: Lack of water/not correct conditions.
Response: Reduction in habitat.
Consequence: Reduction in population numbers, reduction in suitable habitat, elimination of populations.
Narrative: Springhead inundation alters San Bernardino springsnail habitat by causing pools of water to form over spring vents, resulting in ponded water that causes a shift in water depth, velocity, substrate competition, vegetation, and water chemistry. Springhead inundation has affected the San Bernardino springsnail on the John Slaughter Ranch Museum land, and it is speculated that San Bernardino springsnails once occurred in more springs that are now inundated. Inundation has also occurred in Mexico at springs, including some at Los Ojitos ciénega and Ojo El Chorro. These changes in springhead habitat can cause reductions in the San Bernardino springsnail's distribution and abundance. Spring inundation was a big threat in the past, and could continue be a threat to the San Bernardino springsnail in the future.

Stressor: Water Depletion and Diversion
Exposure: Lack of water.
Response: Reduction in habitat.
Consequence: Reduction in population numbers, reduction in suitable habitat, elimination of populations.
Narrative: The greatest threat to the existence of the San Bernardino springsnail (Pyrgulopsis bernardina) is habitat loss attributable to groundwater depletion and diversion. The depletion of underground aquifers can result in the drying of springs. The drying of springs can be severe for San Bernardino springsnails, because they are strictly aquatic. Groundwater depletion and diversion for domestic water use have been recognized as a threat to the San Bernardino springsnail and have resulted in the loss of several populations of the San Bernardino springsnail. Water depletion is also seen as a future threat, because the further depletion of groundwater

sources could eventually contribute to the drying of springs throughout the range of the San Bernardino springsnail, placing the species at increased risk of extinction.

Stressor: Invasive Competitors
Exposure: Nonnative aquatic species.
Response: See narrative.
Consequence: Competition, predation, reduction in population numbers.
Narrative: The potential threat to San Bernardino springsnails (Pyrgulopsis bernardina) from invasive species such as the New Zealand mudsnail and mosquitofish is great; these species could devastate the San Bernardino springsnail population. The control of mudsnails would be difficult; mudsnails are small, and chemical treatment to eradicate them would also eradicate springsnails. The New Zealand mudsnail can outcompete and replace native springsnails, and are a considerable threat to the San Bernardino springsnail's continued existence in the foreseeable future. The nonnative mosquitofish is a predatory threat to the San Bernardino springsnail. Currently, there are no known mosquitofish populations on the San Bernardino NWR or Slaughter Ranch property, but mosquitofish do occur within a quarter mile of the NWR where they currently coexist with San Bernardino springsnails, and have been known to eat the snails (NatureServe 2015; 77 FR 23060).

Stressor: Climate Change and Drought
Exposure: Drought, wildfire.
Response: See narrative.
Consequence: Reduction in population numbers, reduction in suitable habitat, elimination of populations.
Narrative: Loss of water flow is a big threat to the San Bernardino springsnail (Pyrgulopsis bernardina) populations (also see water diversion and spring inundation) and is worsened with extreme drought. Climate change has already proven to increase the severity of droughts. Drying of water channels and bodies related to drought will lead to the potential drying of springs, which will in turn lead to population declines and extirpations of the San Bernardino springsnail. In addition to loss of water flow, continued drying trends will quicken the terrestrial spread of buffelgrass, making San Bernardino springsnail habitats vulnerable to big wildfires in the future.

Stressor: Pesticide
Exposure: Use of pesticides for agriculture.
Response: See narrative.
Consequence: Illness, mortality, defects.
Narrative: Pesticides can be a threat to the San Bernardino springsnail. Private property owners at Slaughter Ranch use a number of pesticides to maintain desirable landscape conditions. Spring endemic species such as the San Bernardino springsnail are adapted to the unique environmental conditions provided by spring water and are sensitive to shifts in water quality, including those caused by contamination. A study found that pesticides affected growth, development, and egg-laying capacity, and cause mortality. According to the Federal Register, normal use of the pesticide glyphosate is not expected to detrimentally affect aquatic biota (77 FR 23060; NatureServe 2015).

Recovery

Reclassification Criteria:

Need to develop a Recovery Plan.

Delisting Criteria:
Need to develop a Recovery Plan.

Recovery Actions:
- Need to develop a Recovery Plan.

Conservation Measures and Best Management Practices:
-

Additional Threshold Information:
-
-

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SPECIES ACCOUNT: *Pyrgulopsis bruneauensis* (Bruneau Hot springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; Pacific Region (R1) (USFWS, 2016)

Physical Description

The Bruneau hot springsnail (Pyrgulopsis bruneauensis) is small, measuring only about 2 millimeters in size. It is found only in geothermal springs and seeps along an 8-kilometer length of the Bruneau River in Southwest Idaho (USFWS, 2016).

Current Range

Survives in 89 of 155 small, flowing geothermal springs and seeps along an approximately 8 km reach of the Bruneau River and its tributary Hot Creek in southwestern Idaho (USFWS, 2002).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Springsnails appear to be opportunistic grazers as food habit studies reveal algal genera are taken in proportions similar to those found in their habitat (Mladenka 1992), However, springsnall densities are lowest In areas of bright green algal mats, while higher snail densities occur where periphyton communities are dominated by diatoms.

Habitat Narrative

Adult: The Bruneau hot springsnail is restricted to thermal springs and seeps and thermally-influenced portions of the river along a 9 km (5.5 mi) segment of the Bruneau River in southwest Idaho. The Bruneau hot springsnail currently occurs in geothermal springs on both the east and west sides of the Bruneau River with a distribution extending 4.4 km (2.73 mi) downstream of the confluence of Hot Creek and the Bruneau River, and 4.4 km (2.73 mi) upstream from the confluence of Hot Creek and within the Bruneau River with sufficient geothermal influence (Mladenka 1992, p. 68). While cooler river temperatures may serve as thermal barriers between occupied springs, high-flow events in the river may scour some spring populations and transport individuals downstream to suitable habitat, supporting gene flow along the river corridor (Mladenka 1992, pg. 83). The species can be found in a variety of habitat types including sands and fine sediments, cobble and boulder, and aquatic vegetation, but is restricted to waters ranging from 11°-35° C (52°-95° F) (Mladenka 1992, pg. 85) (USFWS, 2016).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (USFWS, 2016)

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Resiliency:

Because water table elevation has declined dramatically, much habitat previously inhabited by the snail is dry, resulting in markedly reduced abundance and isolated populations limiting the ability to increase in numbers (Myler et al., 2007). (NatureServe, 2015)

Representation:

Because water table elevation has declined dramatically, much habitat previously inhabited by the snail is dry, resulting in markedly reduced abundance and isolated populations limiting the ability to increase in numbers (Myler et al., 2007). (NatureServe, 2015)

Redundancy:

Because water table elevation has declined dramatically, much habitat previously inhabited by the snail is dry, resulting in markedly reduced abundance and isolated populations limiting the ability to increase in numbers (Myler et al., 2007). (NatureServe, 2015)

Population Growth Rate:

Decline of 50-70% (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Adaptability:

Because water table elevation has declined dramatically, much habitat previously inhabited by the snail is dry, resulting in markedly reduced abundance and isolated populations limiting the ability to increase in numbers (Myler et al., 2007). (NatureServe, 2015)

Population Narrative:

Bruneau hot springsnail populations show declining trends, and connectivity between the remaining colonies has been reduced. Despite previous conservation efforts, threats to the Bruneau hot springsnail persist and it is in danger of extinction (USFWS, 2016). Because water table elevation has declined dramatically, much habitat previously inhabited by the snail is dry, resulting in markedly reduced abundance and isolated populations limiting the ability to increase in numbers (Myler et al., 2007). Decline of 50-70% Ten springs were sampled in 1989 and the total number of snails ranged from one to 17,319 (Mladenka in U.S. Fish and Wildlife Service 1993); populations flucuate seasonally; in some areas densities of >1,000 snails per square meter have been noted (U.S. Fish and Wildlife Service 1993). The greatest mean density at a given site was found to be 8900 per square meter) but ranged to a low of 1782 (Mladenka and Minshall, 2001). Survives in 89 of 155 small, flowing geothermal springs and seeps along an approximately 8 km reach of the Bruneau River and its tributary Hot Creek in southwestern Idaho (USFWS, 2002; Mladenka and Minshall, 2001). It is unknown how many consititute separate populations but in the past they were largely interconnected but increased agricultural use of groundwater has significantly lowered the local water tables and springs are being lost at a rate of ~5 per year and the ramaining are no longer interconnected (Myler et al., 2007). See Frest and Johannes (1998) for recent site details. Lysne and Clark (2009) found it in the Bruneau River (survey area from Snake River confluence upstream to Hot Creek- 41 km) in Idaho. (NatureServe, 2015)

Threats and Stressors

Stressor: Aquifer depletion (USFWS, 2016)
Exposure:
Response:
Consequence: Habitat degradtation
Narrative: Depletion of the geothermal and associated aquifers, resulting in the decline in spring discharge is listed as a threat to this species. Groundwater pumping began in 1896, but increased significantly by the mid-1900s when approximately 5,261 ha (13,000 ac) of land in the Bruneau-Sugar Valley area was irrigated with groundwater (1966). By 1980, this had increased to 8,094 ha (20,000 ac) of groundwater-irrigated lands (USFWS 2007). From 1990 to 2003, groundwater pump rates increased in the Bruneau Valley from approximately 6,000 ac-ft to over 9,000 ac-ft and groundwater elevation at wells adjacent to springsnail populations declined by 3.4 m (11.1 ft) from 1991 to 2004 (USFWS 2007, pg. 15-20) and the analysis of Myler and others (2007, pg. 201) provides evidence of a direct relationship between groundwater pumping and aquifer decline which has led to a decrease in the number of geothermal spring habitat throughout the range of this species (USFWS, 2016).

Stressor: Predation (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: At least one of the major spring systems (Hot Creek) is currently occupied by non-native tropical fish species. Both tilapia and guppies, introduced via the pet-trade, reach high densities in this large geothermal spring and previous research has shown they will readily prey on Bruneau hot springsnails (Myler and Minsahll 1998, p. 53) which were formerly abundant in this spring system (USFWS 2007, pg. 12). Access issues to this private land has prevented more aggressive control efforts, and these fish may disperse to adjacent geothermal springs when river temperatures spike during low flows in the summer. While predation by these non-native species is a major impact to this population of springsnails, and possibly other larger geothermal areas downstream, it is regarded as secondary to aquifer depletion given the limited capacity of most small springs and cold river temperatures to support populations of these tropical fish. Alteration of hot springs by people for use as soaking pools occurs periodically, but seldom occurs at smaller springs and does not always result in springsnail extirpation if disturbance and use are not recurring (USFWS, 2016).

Stressor: Groundwater withdrawal and springflow reduction
Exposure:
Response:
Consequence:
Narrative: Increasing threat – no significant change in groundwater withdrawals resulting in continued springflow reductions (USFWS, 2018).

Stressor: Livestock grazing
Exposure:
Response:
Consequence:
Narrative: Determined a low-ranking threat in 2007 5-year review. Continues to be a low-ranking threat (USFWS, 2018).

Stressor: Surface water diversion
Exposure:
Response:
Consequence:
Narrative: Determined a low-ranking threat in 2007 5-year review for the downstream portion of the range. Continues to be a low-ranking threat (USFWS, 2018).

Stressor: Recreation
Exposure:
Response:
Consequence:
Narrative: Determined a low-ranking threat in 2007 5-year review. Continues to be a low-ranking threat (USFWS, 2018).

Stressor: Inadequate state regulations
Exposure:
Response:
Consequence:
Narrative:

Recovery

Delisting Criteria:
The 2002 recovery plan for the endangered Bruneau hot springsnail detailed objective and measurable criteria for delisting: 1) water levels in the geothermal aquifer are being maintained at 815m (2,674ft) above sea level…; 2) the geothermal springs number more than 200 in October and are well distributed throughout the recovery area; 3) greater than two-thirds of available geothermal springs (approximately 131 geothermal springs) are occupied by medium to high density populations; and 4) regulatory measures are adequate to permanently protect groundwater against further reductions (USFWS, 2018).

Recovery Actions:
- The Service is working with the State of Idaho and other partners in conservation, including private landowners, toward the shared goal of reducing threats and ultimately recovering this species so that it no longer needs protection under the ESA. Conservation actions include efforts to increase and stabilize geothermal water levels. These actions might include: voluntary conservation easements (lease/purchase water rights), irrigation system improvements to reduce agricultural water use, continued monitoring of water levels and snail distribution, control of non-native fish known to prey upon the springsnail, and

establishment of regulatory measures that are adequate to permanently protect the springsnail from future groundwater reductions (USFWS, 2016).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. In the long term, stabilization of the geothermal aquifer is needed to conserve Bruneau hot springsnails. Adkins and Bartolino (2012, p. 23) indicated that decreasing geothermal aquifer pumping closer to the geothermal reach of the Bruneau River would be the most effective groundwater conservation effort. We recommend the Service place elevated emphasis on working with the State of Idaho (e.g., IDWR, OSC, Bruneau River Soil and Water Conservation District) and private landowners to explore possible opportunities to strategically conserve geothermal groundwater. These efforts would not only benefit the species and these unique habitats, but would help sustain the local aquifers for their long-term use and sustained economic contribution to the community. 2. Aside from groundwater conservation, it is critical to investigate other possible conservation actions to ensure the species' survival. Based on early reports, springsnail densities were highest in Hot Creek. While the 1991 flood and ongoing groundwater declines have had irreversible impacts to the habitat in Hot Creek, the creek has changed over the past seven years and conservation options in Hot Creek should be reassessed. For example, removal of nonnative fishes from Hot Creek could be a significant conservation gain for the Bruneau hot springsnail and should be elevated as a conservation objective for the species. 3. Should the downward trends in springs and springsnails continue, the Service and its partners should consider other long-term options such as assisted migration to unoccupied and secure hot spring habitats elsewhere in the Bruneau River watershed. 4. In 2005, the Service obtained both LiDAR and infrared thermal imaging for the Bruneau hot springsnails' recovery area in order to remotely assess geothermal spring distributions. The intent of that effort was to provide a snap-shot of geothermal influences within the recovery area, with the recommendation that similar thermal imaging be conducted periodically (5-year intervals) to better assess geothermal spring trends and, by extrapolation, available geothermal spring habitat for springsnails. This effort was repeated in December 2017 with the use of unmanned drones. We recommend completing the spatial analysis of thermal imaging data between 2005 and 2017 to further refine geothermal habitat availability for the species. 5. There is a need to revise Bruneau hot springsnail monitoring methods to better quantify population and colony size that more appropriately assesses Recovery Criterion 3 (for the species to be considered for delisting – See Section 2.2.3). As defined in current monitoring methods, high density populations/colonies may occur in extremely limited (small) areas (60.8 square centimeter circle, Myler 2006, p. 2), and as such do not represent population wide densities. Therefore, monitoring methods should be reevaluated and modified to better estimate density across entire populations/colonies. Additional monitoring parameters will be developed and modified as necessary to address this need, and incorporated to provide greater resolution to future criteria. 6. While the invasive aquatic plant hydrilla has been successfully reduced to small numbers, continued monitoring and control will be needed to keep this highly competitive invasive species from reestablishing itself within habitat occupied by the Bruneau hot springsnail. 7. With the declining trend in both Bruneau hot springsnail abundance and their habitat, we recommend completing a Population Viability Analysis to determine the extinction probability of this species and the timeframe associated with it (USFWS, 2018).

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SPECIES ACCOUNT: *Pyrgulopsis chupaderae* (Chupadera springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 7/12/2012; Southwest Region (R2) (USFWS, 2016)

Physical Description

Thermal spring snail of the family Hydrobidae, endemic to New Mexico. See Taylor (1987) for morphological description. (NatureServe, 2015)

Taxonomy

his taxon was placed in the genus Pyrgulopsis by Hershler and Thompson (1987) and Hershler (1994) based on re-examination of the type series and published accounts (NatureServe, 2015)

Current Range

This species is endemic to the south end of the Chupadera Mountains in Socorro County, New Mexico, in the Rio Grande drainage; and currently resides in < 20 m of outflow. Formerly, it was probably a resident of the entire cienega, which is less than 5 ha (Hershler, 1994).

Critical Habitat Designated

Yes; 7/12/2012.

Legal Description

On July 12, 2012, the U.S. Fish and Wildlife Service designated critical habitat for Pyrgulopsis chupaderae.

Critical Habitat Designation

The two areas we designate as critical habitat for the Chupadera springsnail are: (1) Willow Spring, which is currently (at the time of listing) occupied and contains the primary constituent elements; and (2) unnamed spring, which is not currently (at the time of listing) occupied but is determined to be essential for the conservation of the species.

Unit 1: Willow Spring Unit. Unit 1 consists of approximately 0.5 ha (1.4 ac) in Socorro County, New Mexico. When last visited in 1999, the Willow Spring Unit was a wet meadow with a springbrook that runs approximately 38 m (125 ft) before being impounded by a berm that crosses the meadow. The entire unit is in private ownership. The Service designated a single critical habitat unit that encompasses Willow Spring and includes the springhead, springbrook, small seeps and ponds, and the seasonally wetted meadow associated with the spring downstream to the artificial berm. This spring is located within the drainage of the Rio Grande, approximately 2.7 km (1.7 mi) west of Interstate Highway 25. The Willow Spring site has documented occupancy of Chupadera springsnail from 1979 to 1999 (Taylor 1987 p. 24; NMDGF 2004, p. 45). Based on observations in 2011 provided by the landowner (Highland Springs, LLC 2011, p. 3), the Service presumes the species persists at Willow Spring. The Willow Spring Unit contains all the primary constituent elements to support all of the Chupadera springsnail's life processes. Threats to the primary constituent elements in this unit that may require special management include the effects of livestock grazing, groundwater depletion, springhead or springbrook modification, water contamination, and potential effects from nonnative species.

Unit 2: Unnamed Spring Unit. Unit 2 consists of approximately 0.2 ha (0.5 ac) in Socorro County, New Mexico. The entire unit is privately owned. The Service is designating a single critical habitat unit that encompasses the unnamed spring and includes the springhead, springbrook, small seeps and ponds, and the seasonally wetted meadow associated with the spring. This spring is located within the drainage of the Rio Grande, approximately 2.7 km (1.7 mi) west of Interstate Highway 25, and about 0.5 km (0.3 mi) north of Willow Spring. The Unnamed Spring Unit is currently unoccupied by the Chupadera springsnail, but it was historically occupied (Stefferud 1986, p. 1; Taylor 1987, p. 24; Lang 1998, p. 36). The spring appears to share a common aquifer and similarities in water chemistry, temperature, and hydrology with Willow Spring. When developing conservation strategies for species whose life histories are characterized by short generation time, small body size, high rates of population increase, and high habitat specificity, it is important to maintain multiple populations as opposed to protecting a single population (Murphy et al. 1990, pp. 41– 51). Having replicate populations is a recognized conservation strategy to protect species from extinction due to catastrophic events (Soule 1985, p. 731). This area is important to prevent extinction of the Chupadera springsnail. Some habitat restoration work may be needed before Chupadera springsnail could be reintroduced to the Unnamed Spring Unit; however, creating a second population is important for the long-term persistence of the species. The Unnamed Spring Unit is essential for the conservation of the species because it is a site where the Chupadera springsnail can be reintroduced.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Socorro County, New Mexico. Within these areas, the primary constituent elements of the physical and biological features essential to the conservation of the Chupadera springsnail consist of springheads, springbrooks, seeps, ponds, and seasonally wetted meadows containing:

(i) Unpolluted spring water (free from contamination) emerging from the ground and flowing on the surface;

(ii) Periphyton (an assemblage of algae, bacteria, and microbes) and decaying organic material for food;

(iii) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for egg laying, maturing, feeding, and escape from predators; and

(iv) Nonnative species either absent or present at low population levels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, roads, and other paved areas, and the land on which they are located) existing on the effective date of this rule.

Threats to the physical and biological features essential to the conservation of the Chupadera springsnail include loss of spring flows due to groundwater pumping and drought, inundation of springheads due to pond creation, degradation of water quality and habitat due to livestock grazing or other alteration of water chemistry, and the introduction of nonnative species.

Life History

Feeding Narrative

Adult: Hydrobiid snails feed primarily on periphyton, which is a complex mixture of algae, bacteria, and microbes that occurs on submerged surfaces in aquatic environments (Mladenka 1992, pp. 46, 81; Allan 1995, p. 83; Hershler and Sada 2002, p. 256; Lysne et al. 2007, p. 649) (USFWS, 2012). This species is a resident of a cienega system with multiple source springs (22 degrees C). Most of the sources have been impounded. The species survives in an outflow Pyrgulopsis is a rheocrene, or a spring emerging from the ground as a free-flowing stream. Pyrgulopsis snails are rarely found on or in soft sediment. Aquatic vegetation within these habitats includes watercress (Nasturtium spp.), Ranunculus, and filamentous green algae. Springsnails are commonly found among watercress. Other associated mollusks include Anodonta californiensis, Valvata humeralis, Physa gyrina, Radix auricularia, Gyraulus parvus, Pisidium casertanum, P. compressum, and P. variabile (USFWS, 2003).SPRING/SPRING BROOKBenthic (NatureServe, 2015)

Reproduction Narrative

Adult: Springsnails in the genus Pyrgulopsis are egg-layers with a single small egg capsule deposited on a hard surface (Hershler 1998, p. 14). The larval stage is completed in the egg capsule, and upon hatching, the snails emerge into their adult habitat (Brusca and Brusca 1990, p. 759; Hershler and Sada 2002, p. 256). The snail exhibits separate sexes; physical differences are noticeable between them, with females being larger than males (USFWS, 2012). These snails likely have life spans of 9-15 months and reproduce several times during the spring to fall breeding season (Taylor, 1987) (NatureServe, 2015).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Unknown (Natureserve, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: This species is a resident of a cienega system with multiple source springs (22 degrees C). Most of the sources have been impounded. The species survives in an outflow. Pyrgulopsis is a rheocrene, or a spring emerging from the ground as a free-flowing stream. Pyrgulopsis snails are rarely found on or in soft sediment. Aquatic vegetation within these habitats includes watercress (Nasturtium spp.), Ranunculus, and filamentous green algae. Springsnails are commonly found among watercress. Other associated mollusks include Anodonta californiensis, Valvata humeralis, Physa gyrina, Radix auricularia, Gyraulus parvus, Pisidium casertanum, P. compressum, and P. variabile (USFWS, 2003). Benthic (NatureServe, 2015). High ecological integrity of the community and site fidelity as well as low tolerance ranges are based on the species specific habitat requirements and the low number of known populations.

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: Unlikely (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Low mobility and dispersal as well as unlikely immigration aare based on the species low number of populations and the lack of suitable habitat for this species to populate/re-populate. This snails is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Unknown (NatureServe, 2015)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

50 - 2500 individuals (NatureServe, 2015)

Population Narrative:

The geographically restricted distribution of the Chupadera springsnail and its apparent extirpation from one of its two known historical sites increase the possibility that a human-caused or natural event could eliminate the species. Stochastic events such as floods, severe droughts, contamination events, or fires could result in the extirpation of one or both populations. Reduced population numbers and localities may result in decreased genetic diversity and increasing vulnerability to extinction due to further stochastic events (USFWS, 2003). These snails likely have life spans of 9-15 months and reproduce several times during the spring to fall breeding season (Taylor, 1987). As this species was only described from specimens collected in the mid-1980s (Taylor, 1987), long-term trends and historical distribution are not known. Unknown In 1993, the population was estimated at < 2,000 individuals in 20 m x 0.5 m outflow. Currently this species is a resident of Willow Spring, on the Willow Spring Ranch (formerly Cienaga Ranch) at the south end of the Chupadera Mountains west of Bosque del Apache National Wildlife Refuge headquarters in Socorro County, New Mexico. It is documented only from two hillside groundwater discharges (Taylor, 1987; Hershler, 1994; Lang, 1998), one of which has been extirpated following cattle trampling (USFWS, 2003). (NatureServe, 2015)

Threats and Stressors

Stressor: Groundwater depletion (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Groundwater pumping and drought both threaten the species habitat (USFWS, 2012).

Stressor: Livestock grazing (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The springheads at both Willow Spring and the unnamed spring have been modified through impoundment of the springbrooks and, at Willow Spring, to maintain a pump and improve water delivery systems to cattle (Lang 1998, p. 59). At Willow Spring, it appears that springbrook impoundment has only occurred downstream of the source, leaving some appropriate springbrook habitat intact upstream (Taylor 1987, p. 26). At the last visit to the Willow Spring in 1999, the habitat at the spring was of sufficient quality to sustain the Chupadera springsnail, but any subsequent alterations could be catastrophic for the species. Spring modification, either at the springhead or in the springbrook, is a threat to the Chupadera springsnail (USFWS, 2012).

Stressor: Small, Reduced Range (USFWS, 2012)
Exposure:
Response:
Consequence: Exctintion
Narrative: The geographically small range of the Chupadera springsnail increases the risk of extinction from any effects associated with other threats (NMDGF 2002, p. 1). When species are limited to small, isolated habitats, like the Chupadera springsnail in one small desert spring system, they are more likely to become extinct due to a local event that negatively effects the population (Shepard 1993, pp. 354–357; McKinney 1997, p. 497; Minckley and Unmack 2000, pp. 52–53) (USFWS, 2012).

Stressor: Inadequacy of Existing Regulatory Mechanisms (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: We found that the New Mexico Office of the State Engineer evaluates proposed water delivery systems if the proposed system is in an area designated as a domestic well management area (Utton Transboundary Resources Center 2011, p. 3). The land being developed around

Willow Spring has not been designated as such and therefore does not provide protections to the habitat of Chupadera springsnail. As discussed in Factor A above, inadequate spring flow due to pumping of the groundwater aquifer by homeowners is a threat to the habitat of the Chupadera springsnail, and the current regulatory mechanisms in place do not alleviate this threat. Additionally, habitat degradation from livestock grazing is also a threat to the Chupadera springsnail, and there are no regulatory mechanisms to protect the springs from the effects of livestock grazing, and so none are evaluated for their adequacy (USFWS, 2012).

Stressor: Introduced Species (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat/loss of individuals
Narrative: The introduction of non-native species to this species habitat is not currently considered a threat (USFWS, 2012).

Stressor: Climate change (USFWS, 2012)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The effects of climate change, while difficult to quantify at this time, are likely to exacerbate the current and ongoing threat of habitat loss caused by other factors, particularly the loss of spring flows resulting from prolonged drought (USFWS, 2012).

Recovery

Recovery Actions:
- No recovery plan has been issued for this species.

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SPECIES ACCOUNT: *Pyrgulopsis neomexicana* (Socorro springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 09/30/1991; Southwest Region (R2) (USFWS, 2016)

Physical Description

The Socorro springsnail has an elongate—ovate conical shell that is light tan, short—spired, and up to 2.5 millimeters (mm) (0.1 inch) in length (New Mexico Department of Game and Fish (NMDGF) 1985). Females are larger than males. The male penis has a long glandular strip on the terminal lobe, a long penial gland, and three shorter dorsal glandular strips (Taylor 1987). Body and head are dark gray to black. Internal callus is reddish brown to amber, and the operculum is pale. Tentacles range from black or dark gray at base to pale gray at tips (Taylor 1987). (USFWS, 1994)

Taxonomy

The species was formally described and named Amnicola neomexicana by Pilsbry (1916). In 1982, Burch reclassified it as Fontelicella neomexicana. Hershler and Thompson (1987) assigned members of the genus Fontelicella, including F. neomexicana, to the genus Pyrgulopsis (USFWS, 1994).

Historical Range

The original specimen of the Socorro springsnail reportedly came from a thermal spring near Socorro, New Mexico. The species is now extinct at the type locality, but the date and cause of the extinction are uncertain (USFWS, 1994).

Current Range

Endemic to central New Mexico where it is known from a 2.4m x 0.3m spring run in Socorro County. It is possible, but unlikely that it persists in the impounded springs in the cienega system, which it is thought to have inhabited before impoundment.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Feeds on algae and other materials that occur in the organic film on plants and debris (USFWS, 1994).

Reproduction Narrative

Adult: The Socorro springsnail is oviparous, and probably lays its eggs in spring and summer (USFWS, 1994).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: Originally inhabited at least one thermal (17 degrees C) spring system and possibly two or more. All habitat has been destroyed except a small 8 ft (2.4m) run from a leak in the base of a windmill. The principal spring source where the snail is found has been impounded, which reduced the flowing-water habitat to a very small pool and one tiny spring source has a small improved pool remains; however, snails were found in the source and outflow tributary (USFWS, 1993). Benthic (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: Unlikely (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: These snails are non-migratory and have low mobility. Chances of dispersal are low and immigration is unlikely because of lack of suitable habitat outside of the one small remaining population (NatureServe, 2015)

Population Information and Trends

Population Trends:

Unknown (USFWS, 2008)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Population Growth Rate:
Decline of 70-90% (NatureServe, 2015)

Number of Populations:
Unknown (USFWS, 2008)

Population Size:
Unknown (USFWS, 2008)

Population Narrative:
The Socorro springsnail is a rare, hydrobiid snail that survives in only one spring located on private land in Socorro County, New Mexico. Access to the site has been denied since 1995. Population numbers are unknown (USFWS, 2008). According to NatureServe (2015), decline of 70-90%. Taylor (1987) estimated its population in 1979 at 5,000, Mehlhop estimated the population in 1993 at < 1,000.

Threats and Stressors

Stressor: Habitat destruction or modification(USFWS, 2008)
Exposure:
Response:
Consequence: Loss of habitat/extinction
Narrative: Because access to Torreon Spring has been denied, the status of the spring habitat and the snail population is unknown. Lack of cooperation by land owner could be viewed as a threat that was not anticipated when Socorro springsnail was listed (USFWS, 2008).

Stressor: Climate change (USFWS, 2008)
Exposure:
Response:
Consequence: Loss of habitat/extinction
Narrative: The effect climate change will have on springs in the southwest is unknown. However, the southwestern U.S. may be entering a period of prolonged drought (McCabe et al. 2004, Seager et al. 2007). Seager et al. (2007) showed that there is a broad consensus among climate models that the Southwest will get drier in the 21st century and that the transition to a more arid climate is already under way. Only one of 19 models examined showed a trend toward a wetter climate in the southwest (Seager et al. 2007). An increase in average mean air temperature of just under 1°C (1.8°F) has already been documented in New Mexico since 1976 (Lenart 2007). Udall (2007) found that multiple independent data sets confirm widespread warming in the western U.S. (USFWS, 2008).

Stressor: Localized range (USFWS, 2008)
Exposure:
Response:
Consequence: Extinction
Narrative: Having a small, localized range means that any perturbation (e.g., drought, water contamination) can eliminate the species. Having a high number of individuals at a site provides no protection against extinction. Noel (1954) noted that an amphipod (another aquatic

invertebrate) in Lander Spring, New Mexico was the most abundant animal present when she did her research. The species was extirpated from that site when the spring dried up (Cole 1985) (USFWS, 2008).

Stressor: Limited dispersal capability (USFWS, 2008)
Exposure:
Response:
Consequence: Extinction
Narrative: Extremely limited dispersal capability effectively eliminates the ability of the spingsnail to find and disperse to other suitable habitats or to move out of habitat that becomes unsuitable. Consequently, they are unable to avoid contaminants or other unfavorable changes to their habitat (USFWS, 2008).

Stressor: Predation (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Although the introduction of predaceous nonnative species is a potential threat, because of the restricted access, the likelihood that non-natives have been introduced is reduced. However, spring impoundment would create more favorable habitat for bullfrogs, crayfish, and nonnative fishes. It is unknown if non-natives are present at the site (USFWS, 2008).

Recovery

Reclassification Criteria:
1. A habitat management plan is formulated that provides protection of the species and its habitat (USFWS, 2008).

2. The habitat management plan is in place at least 5 years and demonstrates that the continued existence of the Socorro springsnail population is assured under the conditions of the habitat management plan (USFWS, 2008).

Delisting Criteria:
1. Protection of the springsnail's habitat in perpetuity can be assured (USFWS, 2008).

2. Additional populations can be successfully established, as evidenced by recruitment and persistence over a period of 5 consecutive years, in habitat that was likely to have been historically occupied by the springsnail while the habitat management plan continues to provide protection for the habitat of the original populations (USFWS, 2008).

Recovery Actions:
- 1. Work with landowners to develop a Habitat Management Plan for protection of springanails' habitats. With cooperation of landowners and other interested agencies, groups, or individuals, a HMP should be developed that will provide for the continuation of the Alamosa and Socorro springsnails in their historic habitat. This plan should specifically focus on the historic use of land surrounding the springs and continuation of that use. (USFWS, 1993).

- 2. Monitor and evaluate existing populations and their habitat. A monitoring program should be established to determine the health of the populations of the Alamosa and Socorro springsnails and determine the condition of their habitat. To be effective, this program should be initiated with approval of this plan and continue for at least 5 years after recovery has been achieved. Monitoring should be conducted twice annually according to an established protocol. (USFWS, 1993).
- 3. Determine life history and ecological needs (USFWS, 1993).
- 4. Locate site and establish second populations of the species in presumed historic habitat, but disjunct from existing populations (USFWS, 1993).

Conservation Measures and Best Management Practices:

- The recovery plan needs to be revised and updated. Because the habitat and management of the habitat of the Socorro springsnail is so different from that of the Alamosa springsnail and because the plan is out-of-date for both species, it is recommended that revised recovery plans be written for each species (USFWS, 2008).
- Continue efforts to gain access to the spring (USFWS, 2008).
- If access is granted, conduct life history studies, monitor population numbers, determine attributes of suitable habitat (substrate, water temperature limits, pH, hardness, alkalinity etc.). Set up long-term monitoring of discharge and temperature (USFWS, 2008).
- If access continues to be denied, attempt to set up a one-time visit to the spring to collect individuals for a captive refugium population (USFWS, 2008).

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SPECIES ACCOUNT: *Pyrgulopsis ogmorhaphe* (Royal marstonia (snail))

Species Taxonomic and Listing Information

Listing Status: Endangered; April 15, 1994; Southeast region (R4)

Physical Description

The royal snail is a small (usually less than 5 mm in length) annual species distinguished from other closely related species by (1) its relatively large size; (2) its large number of whorls (5.2-5.8); (3) its deeply incised, suture-producing, strongly shouldered whorls, which are almost flat; (4) its complete aperture, which is broadly ovate in shape with a rounded posterior corner; (5) its outer lip, which is slightly arched forward in lateral profile; (6) its thin shell; (7) its conical terete shape; and (8) its enlarged bursa copulatrix with a completely exposed duct (Thompson 1977) (USFWS, 1994).

Taxonomy

Herschler and Thompson (1987) synonymized Marstonia with Pyrgulopsis largely based on morphological characteristics of P. nevadensis (the poorly known type species of Pyrgulopsis). However, based on strongly differentiated morphological characteristics between eastern and western congeners of Pyrgulopsis, Thompson and Herschler (2002) re-evaluated eastern North American species assigned to Pyrgulopsis and recognized them as distinct species of the genus Marstonia. Since it is published, peer-reviewed, and uncontested, this assignment to Pyrgulopsis stands as taxonomically valid and should be reflected in the next American Fisheries Society publication of common and scientific names of aquatic invertebrates from the United States and Canada (expected to be published in a year or two). The Integrated Taxonomic Information System (IT IS 2011) lists both M. ogmorhaphe and P. ogmorhaphe as valid, although only P. ogmorhaphe shows a record credibility rating of “verified,” meaning all standards have been met (USFWS, 1994).

Historical Range

See current range/distribution.

Current Range

Known from two spring runs in the Sequatchie River system in Marion County, Tennessee (Owen Spring and Town Creek) (USFWS, 1994).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Not available

Reproduction Narrative

Adult: This species is believed to have a one year life cycle.

Geographic or Habitat Restraints or Barriers

Adult: Does not occur far from spring outflow

Spatial Arrangements of the Population

Adult: Clumped distribution

Environmental Specificity

Adult: Narrow

Tolerance Ranges/Thresholds

Adult: Low (see threats)

Habitat Narrative

Adult: Royal snails occupy spring runs flowing out of two caves in the Sequatchie River system. They are generally found in the diatomaceous “ooze” and on leaves and twigs in the quieter pools downstream from the spring source. This species is subject to sudden extinction should its habitat deteriorate. No other life history information is known. The snail is found in about a 50-meter (150-foot) stretch of the spring outflow, about 50 meters (150 feet) from where surface flow begins (USFWS, 1995).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Stable

Resiliency:

Low

Representation:

Currently being assessed

Redundancy:

Low

Number of Populations:

Two

Population Narrative:

Because both existing populations inhabit extremely limited areas, they are vulnerable to extirpation from accidental toxic chemical spills or vandalism. The two extant occurrences of the royal marstonia were visited repeatedly during the 2003 survey and appeared to be stable. Beginning in 2012, the genetic diversity between the Owen Spring and Town Creek populations will be valuated with mitochondrial DNA sequencing, to examine the relationship between the two populations. If the COI gene is found to be insufficiently sensitive for this purpose, the first internally transcribed spacer region (ITS-1) between the 5.8S and 18S ribosomal DNA genes will be sequenced as well. In 2007, both populations were observed to be plentiful in the headwaters of the two drainages, although both populations were constrained by beaver activity in downstream areas (Withers 2007) (USFWS, 2011).

Threats and Stressors

Stressor: Degradation of water quality (USFWS, 1995).
Exposure:
Response:
Consequence:
Narrative: Potential degradation of the water quality of the two spring runs is the most significant threat to the species' continued survival. Because the royal snail is believed to have a 1-year life cycle, it is subject to sudden extinction should its habitat deteriorate, even for a short period, to the point where a single year's reproduction fails or is significantly reduced. Human-related activities that could prove detrimental to the water quality of the spring runs (by causing or increasing siltation, nutrient, or pollutant loading or by altering water levels, temperature, or pH) include, but are not limited to, increased development, indiscriminate logging and other land use changes, stream alteration (such as channelization or impoundment), withdrawal of water, road and bridge construction, runoff of pesticides and fertilizers, leachate from septic systems and coal mines, and other point and nonpoint pollution discharge. Further, these impacts could possibly come from distant sources because the recharge areas for the springs could extend for several miles (USFWS, 1995).

Stressor: Nonnative Species (USFWS, 1995).
Exposure:
Response:
Consequence:
Narrative: The invasion or introduction of nonnative aquatic weeds (e.g., Hydrilla) into the spring runs could result in the elimination of the habitat required by the royal snail and require intensive and potentially harmful control measures. Another concern is the zebra mussel (Dressena polymorpha). There is fear that the tremendous filtering activity exerted by high-density populations of this species could disrupt the natural food chain and affect entire aquatic communities of infested lakes and streams (Weigmann et al. 1991). However, it is not clear whether the zebra mussel can colonize headwater streams such as those occupied by the royal snail (USFWS, 1995).

Recovery

Reclassification Criteria:
The recovery plan did not identify recovery criteria for the species.

Delisting Criteria:
We are proposing that the Royal Snail should be considered for delisting when the following criteria are met: 1) The two (2) existing populations occupying Town Creek and Owen Spring Branch exhibit stable or increasing trends, evidenced by natural recruitment, and multiple age classes. 2) Threats have been addressed and/or managed to the extent that the species will remain viable for the foreseeable future (USFWS, 2019).

Recovery Actions:

- 1. Protect the existing population and essential habitat (USFWS, 1995).
- 2. Identify threats to the species, conduct research necessary for the species' management, and implement management where needed (USFWS, 1995).
- 3. Develop artificial holding and propagation techniques and, if feasible, establish captive populations (USFWS, 1995).
- 4. Develop and implement cryogenic techniques to preserve the species' genetic material (USFWS, 1995).
- 5. Develop and implement a program to monitor royal snail population levels and water and/or habitat conditions of each of the spring runs
- 6. Annually assess the overall success of the recovery program and recommend action (changes in recovery objectives, continue to protect, implement new measures, other studies, etc.) (USFWS, 1995).

Conservation Measures and Best Management Practices:

- Restore degraded habitat in both the Town Creek and Owen Spring Branch drainages, with priority given to those areas closest to occupied habitat. Implement a long-term beaver control program where needed and investigate the need for and potential to regulate flow from "The Lagoon" into the Owen Spring Branch.
- Delineate the recharge zone for both springs.
- Within the recharge zone, protect habitat on public lands through formal agreements and management plans. Work with the Town of Jasper to develop and implement a plan to provide for conservation of the royal marstonia in the vicinity of, and downstream of, the Jasper Water Plant.
- Within the recharge zone, protect habitat on private land through acquisitions and easements where possible.
- Investigate approaches to estimating population abundance. Develop a protocol for and implement a program to monitor important royal marstonia population parameters (USFWS, 2011).
- Develop a program for monitoring water quality and habitat conditions in occupied habitat (USFWS, 2011).
- Develop artificial holding and propagation technology (USFWS, 2011).
- Investigate genetic differences between the two populations of royal marstonia (USFWS, 2011).
- Form an informal recovery group comprised of a broad array of stakeholders to better facilitate periodic discussion of and implementation of recovery activities (USFWS, 2011).

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SPECIES ACCOUNT: *Pyrgulopsis roswellensis* (Roswell springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/09/2005; Southwest Region (R2) (USFWS, 2016)

Physical Description

Thermal spring snail of the family Hydrobiidae from the Roswell area of the Pecos River Valley. See Taylor (1987) for morphological description.Very small with a narrowly conical tan shell with up to 5 whorls (FWS, 2005). (NatureServe, 2015)

Taxonomy

Although their shells are similar, the Roswell springsnail is distinguished from Koster's springsnail by a dark, amber operculum (a lid which closes the shell opening when the animal is retracted) with white spiral streaks, while that of Koster's springsnail is nearly colorless. The genus Assiminea can be determined from other snail genera by an almost complete lack of tentacles, leaving the eyes within the tips of short eye stalks (Taylor 1987) (USFWS, 2005).

Current Range

Endemic to the Roswell area of the Pecos River Valley in New Mexico. Less than 9 km between the most distant populations. Formerly occurred at sites at least 20 km apart.

Critical Habitat Designated

Yes; 6/7/2011.

Legal Description

On June 7, 2011, the U.S. Fish and Wildlife Service designated critical habitat for Pyrgulopsis roswellensis.

Critical Habitat Designation

Approximately 70.2 ac (28.4 ha) in two units in New Mexico as critical habitat for the Roswell springsnail.

Unit 1: Sago/Bitter Creek Complex. Unit 1 consists of 31.9 ac (12.9 ha) of habitat that was occupied by all four invertebrates (Pecos assiminea (Assiminea pecos), Roswell springsnail (Pyrgulopsis roswellensis), Koster's springsnail (Juturnia kosteri), and Noel's amphipod (Gammarus desperatus)) at the time of listing and that remains occupied at the present time. Unit 1 is located on the northern portion of the Middle Tract of Bitter Lake National Wildlife Refuge, Chaves County, New Mexico. The designation includes all springs, seeps, sinkholes, and outflows surrounding Bitter Creek and the Sago Springs complex. Habitat in this unit is in need of special management because of threats by subsurface oil and gas drilling or similar activities that contaminate surface drainage or aquifer water; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. The entire unit is owned by the Service.

Unit 2a: Springsnail/Amphipod. Impoundment Complex Unit 2a consists of 38.3 ac (15.5 ha) of habitat that was occupied by three of the four invertebrates at the time of listing and that remains occupied at the present time. Unit 2a is located on the southern portion of the Middle Tract of Bitter Lake National Wildlife Refuge and on property owned by the City of Roswell, Chaves County, New Mexico. This unit includes portions of impoundments 3, 6, 7, and 15, and Hunter Marsh. The designation includes all springs, seeps, sinkholes, and outflows surrounding the Refuge impoundments. Habitat in this unit is threatened by subsurface drilling for oil and gas or similar activities that contaminate surface drainage or aquifer water; wildfire; and nonnative fish, crayfish, snails, and vegetation. Therefore, the essential physical and biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats. Land ownership in this unit includes the Service and the City of Roswell, New Mexico.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Chaves County, New Mexico. The primary constituent element of critical habitat for the Koster's springsnail and Roswell springsnail is springs and spring-fed wetland systems that:

(i) Have permanent, flowing water with no or no more than low levels of pollutants;

(ii) Have slow to moderate water velocities;

(iii) Have substrates ranging from deep organic silts to limestone cobble and gypsum;

(iv) Have stable water levels with natural diurnal (daily) and seasonal variations;

(v) Consist of fresh to moderately saline water;

(vi) Vary in temperature between 50– 68 °F (10–20 °C) with natural seasonal and diurnal variations slightly above and below that range; and

(vii) Provide abundant food, consisting of: (A) Algae, bacteria, and decaying organic material; and (B) Submergent vegetation that contributes the necessary nutrients, detritus, and bacteria on which these species forage.

Special Management Considerations or Protections

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 the effective date of this rule.

Special management considerations are needed to protect the habitat of this species from the loss or alteration of spring habitat as a result of drought or pumping.

Special management efforts are needed to protect the habitat of this species from the potential effects of water contamination from oil and gas operations, agricultural activities, wastewater effluent, and stormwater runoff.

Special management efforts are needed to correctly plan prescribed fires in order to protect the habitat of this species from the potential effects of wildfire.

Special management efforts are needed to protect this species from the potential effects of invasive, nonnative terrestrial plants and invasive, nonnative snails.

Life History

Feeding Narrative

Adult: The snails feed on algae, bacteria, and decaying organic matter; and will incidentally ingest small invertebrates while grazing on algae and detritus (USFWS, 2010).; The Roswell springsnail and Koster's springsnail have lifespans of 9 to 15 months and reproduce several times during the spring through fall breeding season (Taylor, 1987; Pennak, 1989). No information exists on frequency of breeding, fecundity, or other aspects of reproduction of Pecos assiminea. (NatureServe, 2015)

Reproduction Narrative

Adult: Lifespan of 9 to 12 months and reproduced several times during the spring through fall breeding season; also sexually dimorphic with females characteristically larger and longer-lived than males (FWS, 2005).; Assiminea pecos, Juturnia kosteri, Pyrgulopsis roswellensis, and the amphipod Gammarus desperatus are often found together associated with aquifer-fed, spring systems in desert grasslands of the Pecos River basin with abundant "karst" topography (USFWS, 2010). ; (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: Species is found on pebbles, gypsum silt and to a lesser extent mud and submerged vegetation in seeps and high volume springs and spring runs. Co-occurs with TRYONIA KOSTERI. Occupies spring heads and runs with variable water temperatures (10-20C) and slow-to-moderate water velocities over compact substrate ranging from deep organic silts to gypsum sands and gravel and compact substrate (FWS, 2005). Benthic (NatureServe, 2015). Clumped arrangements of the population, narrow environmental specificity, high ecological integrity of the community, high site fidelity and low tolerance ranges are based on the species specific habitat requirements, small geographic range and low number of known populations.

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: Unlikely (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Low mobility and dispersal as well as unlikely immigration are based on the snails specific habitat requirements, isolated populations and physiological characteristics as does the species being classified as non-migrant (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1000 - 2500 individuals (NatureServe, 2015)

Population Narrative:

Dependent on flowing water of high quality, although it can be mineral rich. Localized range, limited mobility, fragmented habitat (FWS, 2005). Decline of 50-70%. Abundant at Sago Spring with thousands of individuals present. Less common in Bitter Creek (Lost River) Spring run, which is > 1.5 km in length. Small populations of < 1,000 individuals each at a seep and a disturbed spring. Known from two high volume flow springs and spring runs, at least one seep and one highly modified spring all on the Bitter Lake National Wildlife Refuge (Bitter Creek. Sago Spring, Sinkhole No. 31, and along the western boundary of Unit 6) (NM Game and Fish, 2004). Currently known only from Bitter Lake National Wildlife Refuge with the core population in the Sago Springs Complex and Bitter Creek (total linear 2 km) (FWS, 2005). Extirpated from two other sites (NatureServe, 2015). Low representation, resiliency and redundancy are based on the species habitat requirements and low number of populations.

Threats and Stressors

Stressor: Reduction of Water in Springs (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: These four invertebrates depend on water for survival. Therefore, the loss or alteration of spring habitat continues to be the main threat to each of the four invertebrates. The scattered distribution of springs makes them aquatic islands of unique habitat in an arid-land matrix (Myers and Resh 1999). Members of the snail family Hydrobiidae (including Roswell and Koster's springsnails) are susceptible to extirpation or extinction because they often occur in isolated desert springs (Hershler 1989, Hershler and Pratt 1990, Hershler 1994, Lydeard et al. 2004). There is evidence these habitats have been historically reduced or eliminated by aquifer depletion (Jones and Balleau 1996). The lowering of water tables through aquifer withdrawals for irrigation and municipal use has degraded desert spring habitats, which the three snails and Noel's amphipod depend upon for survival. At least two historic sites for the invertebrates (South Spring, Lander Spring) are currently dry due to aquifer depletion (Cole 1981, Jones and Balleau 1996), and Berrendo Spring, historical habitat for the Roswell springsnail, is currently at 12 percent of the 1880s flow. However, during the mid-1970s, the areas currently occupied by the species continued to flow, even though groundwater pumping was at its highest rate and the area was experiencing extreme drought (McCord et al. 2007). This suggests these springs and seeps may be somewhat resilient to reduced water levels (USFWS, 2010).

Stressor: Water Contamination (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat/loss of individuals
Narrative: Water contamination, particularly from oil and gas operations, is a significant threat for these four invertebrates. In order to assess the potential for contamination, a study was completed in September 1999 to delineate the area that serves as sources of water for the springs on the Refuge (Balleau Groundwater, Inc. 1999). This study reported that the sources of water that will reach the Refuge's springs include a broad area beginning west of Roswell near Eightmile Draw, extending to the northeast to Salt Creek, and southeast to the Refuge. This area represents possible pathways from which contaminants may enter the groundwater that feeds the springs on the Refuge. This broad area sits within a portion of the Roswell Basin and contains a mosaic of Federal, State, City, and private lands with multiple land uses including expanding urban development (USFWS, 2010).

Stressor: Fire (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The effects of wildfire to these four invertebrate species could be catastrophic and pose a threat to at least the Roswell and Koster's springsnails and Noel's amphipod. As such, strategically timed prescribed burns throughout their range significantly reduce fuel loads, limiting the risk of detrimental wildfires (USFWS, 2010).

Stressor: Overutilization for commercial, recreational, scientific, or educational purposes (USFWS, 2010)

Exposure:
Response:
Consequence: Loss of individuals
Narrative: Roswell springsnail, Koster's springsnail, Pecos assiminea, and Noel's amphipod may occasionally be collected as specimens for scientific study, but these uses have a negligible effect on total population numbers. These species are currently not known to be of commercial value, and overutilization has not been documented. However, as their rarity becomes known, they may become more attractive to collectors. Although scientific collecting is not presently identified as a threat, unregulated collecting by private and institutional collectors could pose a threat to these locally restricted populations. We are aware of overcollection being a potential threat with other snails (e.g., armored snail (Pyrgulopsis (Marstonia) pachyta) (65 FR 10033, February 25, 2000); Bruneau hot springsnail (P. bruneauensis) (58 FR 5938, January 25, 1993); and Socorro springsnail (P. neomexicana) and Alamosa springsnail (Tryonia alamosae) (56 FR 49646, September 30, 1991), due to their rarity, restricted distribution, and generally well known locations. Due to the small number of localities for the four invertebrates, these species are vulnerable to unrestricted collection, vandalism, or other disturbance. There is no documentation of collection as a significant threat to any of the species. Therefore, we believe that collection of the animals is a minor but present threat (USFWS, 2010).

Stressor: Predation (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Springsnails and amphipods are a food source for other aquatic animals. Juvenile springsnails appear vulnerable to a variety of predators. Damselflies (Zygoptera) and dragonflies (Anisoptera) have been observed feeding upon snails in the wild (Mladenka 1992). Damselflies and dragonflies are native and abundant on the Refuge and their aquatic larvae most likely prey upon both the springsnails and Noel's amphipod. Springsnails are vulnerable to predation by fish (Kennedy 1977; Winemiller and Anderson 1997). Mladenka (1992) found that guppies would feed on springsnails in the laboratory. Nonnative fish present on the Refuge (primarily common carp, Cyprinus carpio) most likely also prey upon the springsnails and Noel's amphipod when they occur in the same habitats. The extent to which predation from nonnative fish affects population size of the three aquatic invertebrates is not known. Predation pressure on the semiaquatic Pecos assiminea is also unknown. However, if the decollate snail (Rumina decollata), a nonnative predatory snail, becomes established on the Refuge, the potential exists for it to prey on Pecos assiminea. The decollate snail was introduced to the United States in the early 1800s in South Carolina and spread westward (Selander and Kaufman 1973). It was reported in Arizona in 1952 and California in 1966 but was well established by the time it was discovered (Selander and Kaufman 1973). It is common in Texas (Selander and Kaufman 1973) and has been reported from the Roswell area in New Mexico (Lang 2005b). It inhabits gardens and agricultural areas and is primarily terrestrial, but has also invaded riparian and other native habitats (Selander and Kaufman 1973). It is used in California as a biological control agent against the brown garden snail (Helix aspera) (Cowie 2001). It will consume native snails (Cowie 2001) as well as vegetation (Dundee 1984). For these reasons, the decollate snail is a potential threat to Pecos assiminea (USFWS, 2010).

Stressor: Predation and competition (USFWS, 2010)
Exposure:

Response:
Consequence: Loss of individuals
Narrative: Nonnative aquatic species such as crayfish, fish, and aquatic snails are also a potential threat to the four invertebrates. There are three native and three nonnnative species of crayfish in New Mexico, but their distributions do not overlap with that of the four invertebrates (Hobbs 1991; B. Lang, NMDGF, pers. comm., 2010). Crayfish are typically opportunistic generalists (they will eat anything and everything) (Hobbs 1991) and their predation on invertebrates is well documented (Hobbs 1991; Lodge et al. 1994; Charlebois and Lamberti 1996; Strayer et al. 1999). Additionally, because they also feed on organic debris and vegetation and reduce algal biomass (Charlebois and Lamberti 1996), they could potentially compete with Roswell springsnail, Koster's springsnail, and Noel's amphipod for food resources. Currently nonnative crayfish are not present on the Refuge or the sites in Texas. Diamond Y Springs Complex does have an undescribed native crayfish that we do not believe to be a concern for Pecos assiminea. However, crayfish have created major problems in aquatic systems in Arizona, and there is no physiological reason why some species of crayfish could not survive in the habitats that now support the four invertebrates. Eradication of crayfish once they are established is extremely difficult (Hyatt 2004). Should crayfish become established in habitats occupied by the four invertebrates, crayfish would pose a potential threat via predation and competition. Nonnative fish have had a major impact on native aquatic fauna in the southwest (Minckley and Douglas 1991; Desert Fishes Team 2003). Communities of animals evolved together and developed adaptations to deal with competition and predation from other members of the community (Meffe et al. 1994). When a nonnative species is introduced into this community, the native members often do not have defenses against predation or they may be less successful competitors. As a result, the nonnative species can have a major impact on native populations (Minckley and Douglas 1991; Meffe et al. 1994). Common carp, a nonnative species, is known to co-occur with the three aquatic invertebrates on the Refuge. Native to Asia, common carp was introduced into the United States in 1831, has become widely distributed (Sublette et al. 1990), and is present on the Refuge in habitats occupied by the invertebrates. It is an omnivore that feeds on aquatic invertebrates, fish eggs, algae, plants, and organic matter (Sublette et al. 1990). In addition, through spawning and feeding behavior it uproots vegetation and increases turbidity (Sublette et al. 1990). Because of its non-discriminatory diet and habitat disturbance, the introduced common carp could have an impact on the three aquatic invertebrate species. Mosquitofish (Gambusia affinis) is also present in some of the spring systems on the Refuge, but it is not known if it is native to the area or not. The species is native to portions of New Mexico, but it has also been widely introduced to control mosquitoes (Sublette et al. 1990). However, it has negatively affected or extirpated many native species of fish and invertebrates (e.g., through predation or hybridization) (Meffe et al. 1994). It is not known if mosquitofish are affecting the three species of aquatic invertebrates (USFWS, 2010).

Stressor: Introduced Species (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Introduced species are one of the most serious threats to native aquatic species (Williams et al. 1989, Lodge et al. 2000). Because the distribution of the four invertebrates is so limited and their habitat is so restricted, introduction of certain nonnative species into their habitat could be devastating. Building upon the list of nonnative aquatic species, such as crayfish, fish, and aquatic snails, discussed under Predation and competition in section 2.3.2.3, below is a

discussion of additional nonnative plants and animals that could negatively impact the four invertebrates. Plants Several invasive terrestrial plant species that may affect the invertebrates are present on the Refuge, including saltcedar (Tamarix spp.), common reed, and Russian thistle (tumbleweed) (Salsola spp.). Control and removal of nonnative vegetation is a factor responsible for localized extirpations of populations of Pecos assiminea in Mexico and New Mexico (Taylor 1987), but uncontrolled nonnative vegetation invasion is also likely detrimental to the species. Saltcedar, found on the Refuge and at Diamond Y Spring Complex and East Sandia Spring, threatens spring habitats primarily through displacement of native plants, shading and/or cooling of spring runs, and from the chemical composition of the leaves and sap that drop to the ground and into the springs. Saltcedar leaves that fall to the ground and into the water increase the salinity of the system, as their leaves contain salt glands (DiTomaso 1998). Additionally, dense stands of common reed choke the stream channel, slowing water velocity and creating more pool-like habitat; this habitat is less suitable for Roswell and Koster's springsnails, which prefer flowing water. Finally, Russian thistle (tumbleweed) can create problems in spring systems by being blown into the channel, slowing flow and overloading the system with organic material (Service 2005b). The specific and limited habitat of the four invertebrates is vulnerable to invasion by these introduced plants, posing the potential for habitat degradation by a moderate threat to the four invertebrates. Mollusks Nonnative mollusks have affected the distribution and abundance of native mollusks in the United States. Of particular concern for three of the invertebrates (Noel's amphipod, Roswell springsnail, and Koster's springsnail) is the red-rim melania (Melanoides tuberculatus), a snail that can reach tremendous population sizes and has been found in isolated springs in the west. The red-rim melania has caused the decline and local extirpation of native snail species, and it is considered a threat to endemic aquatic snails that occupy springs and streams in the Bonneville Basin of Utah (Rader et al. 2003). It is easily transported on fishing boats and gear or aquatic plants, and because it reproduces asexually (individuals can develop from unfertilized eggs), a single individual is capable of founding a new population. It has become established in isolated desert spring ecosystems such as Ash Meadows, Nevada, and Cuatro Cienegas, Mexico, and within the last 15 years, the red-rim melania has become established in Diamond Y Springs Complex (Echelle 2001). It has become the most abundant snail in the upper watercourse of the Diamond Y Springs Complex (Echelle 2001). In many locations, this exotic snail is so numerous that it dominates the substrate in the small stream channel. The effect the species is having on native snails is not known; however, because it is aquatic it probably has less effect on Pecos assiminea than on the other endemic aquatic snails present in the spring. Snails The New Zealand mudsnail (Potamopyrgus antipodarum) is also a potential threat to the endemic aquatic snails on the Refuge and the spring systems in Texas. It was discovered in the Snake River, Idaho, in the mid-1980s and has quickly spread to every Western state except New Mexico (Montana State University 2010). Like the red-rim melania, the New Zealand mudsnail has an operculum (a lid to close off the shell opening), can withstand periods of drying up to eight days (thereby facilitating transport) and can reproduce either sexually or asexually. Thus, new populations can be established with transport of a single individual. In addition, the New Zealand mudsnail is tiny (3 mm [0.12 in] in height), is easily overlooked on gear or shoes, and can be transported unknowingly by people visiting various recreational sites. Considering its current rate of expansion and the availability of suitable habitat, it is highly likely that the New Zealand mudsnail will soon be discovered in New Mexico. The New Zealand mudsnail tolerates a wide range of habitats, including brackish water. Densities are usually highest in systems with high primary productivity, constant temperatures, and constant flow (typical of spring systems). It has reached densities exceeding 500,000 per square meter (46,400 per square foot) (Richards et al. 2001) to the detriment of native invertebrates.

Not only can it dominate the invertebrate assemblage (97 percent of invertebrate biomass), it can also eat nearly all of the algae and diatoms growing on the substrate, altering ecosystem function at the base of the food web (food is no longer available for native animals) (Hall et al. 2003). If the New Zealand mudsnail is introduced into the spring systems harboring the four invertebrates, control would most likely be impossible because the snails are so small and because any chemical treatment would also affect the native species. The impact could be devastating. Trematodes Infestation by trematodes (a flatworm or fluke, phylum Platyhelminthes) was noted by Taylor (1987) in populations of Koster's springsnail at Sago Spring on the Refuge. Digenetic trematodes (trematodes in the order Digenera) are parasitic and have the most complicated life histories in the animal kingdom involving two to four intermediate (vertebrate and/or invertebrate) hosts (Hickman et al. 1974). The first larval stage of the trematode nearly always uses a mollusk (snail or bivalve) as the first intermediate host (Hickman et al. 1974). Larval trematode parasites reduce or completely inhibit snail reproduction through castration (Minchella et al.1985). The effect of the trematodes on the springsnail population is not known (USFWS, 2010).

Stressor: Population Dynamics (USFWS, 2010)
Exposure:
Response:
Consequence: Exctinction
Narrative: Several biological traits have been identified as putting a species at risk of extinction (McKinney 1997, O'Grady et al. 2004). Some of these characteristics include having a localized range, limited mobility, and fragmented habitat (Noss et al. 2006, Fagan et al. 2002). The four invertebrate species each have all of these characteristics. Having a small, localized range means that any perturbation (e.g., drought, water contamination) can eliminate the species. Having a high number of individuals at a site provides no protection against extinction. Noel (1954) noted that Noel's amphipod in Lander Spring, New Mexico was the most abundant animal present when she did her research. The species was extirpated from that site when the spring dried up (Cole 1985). Extremely limited dispersal capability effectively eliminated the ability of the amphipod to find and disperse to other suitable habitats or to move out of habitat that becomes unsuitable. Consequently, the amphipod and snails are unable to avoid pollution or other unfavorable changes to their habitat. Severe drought or wildfire, groundwater pollution and spring contamination, or spring development (impoundment, dredging, piping) could result in the extirpation or extinction of the species (USFWS, 2010).

Stressor: Climate Change (USFWS, 2010)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Increased air temperatures lead to higher evaporation rates, which may reduce the amount of runoff, groundwater recharge, and consequently spring discharge. Increased temperatures across the southwest may also increase the extent of area influenced by drought (Lenart 2003), decreasing groundwater recharge regionally, thereby reducing spring discharge. Prolonged drought leading to diminishment or drying of the spring would have a negative impact on the four invertebrates. Springs would not have to dry out completely to have an adverse effect. Decreased spring flow could lead to a decrease in the amount of suitable habitat, increased water temperature fluctuations, lower dissolved oxygen levels, and an increase in salinity (MacRae et al. 2001). In addition, as water becomes increasingly scarce, conflict over its

use becomes more intense. Human and cattle consumption of water would be expected to increase during drought. Any of these factors, alone or in combination, could lead to either the reduction or extirpation of the populations. Thus, climate change is a significant threat to these four invertebrate species into the foreseeable future (USFWS, 2010).

Recovery

Reclassification Criteria:
1: Maintain the presence of each species in the occupied Management Units (MUs) as of the start of this plan, with a stable or increasing average trend in density over 10 years at currently monitored MUs (MUs 1 and 3) (USFWS, 2018). 2: Develop, implement, and fulfill a water management plan, supported by the local irrigation district and other partners, that ensures adequate surface and groundwater levels to 1) sustain downlisting criteria measured by Criterion 1 above, and 2) meet or exceed BLNWR's minimum federally reserved water right flow (0.0042 m3 /s (0.15 cfs)) for 10 years (USFWS, 2018). 3a: Long-term commitments are in place and will continue to maintain sufficient water quality protections over at least 10 years, and water quality sustains each species as measured by Criterion 1 above (USFWS, 2018). 3b: Long-term commitments are in place that would specifically address the four invertebrates and reduce the risk of a catastrophic spill occurring within a drainage or recharge area occupied by any of the four invertebrates over 10 years (USFWS, 2018). 4: A habitat management plan is developed and implemented that ensures that the environment remains as suitable habitat that sustains each species for 10 years (USFWS, 2018).

Delisting Criteria:
1: Maintain the presence of each species in the occupied MUs as of the start of this plan, with a stable or increasing average trend in density over 20 years in MUs 1 and 3 (USFWS, 2018). 2: Develop, implement, and fulfill a water management plan, supported by the local irrigation district and other partners, that ensures adequate surface and groundwater levels to 1) sustain delisting criteria measured by Criterion 1 above, and 2) ensure that the flows in Bitter Creek as measured at the Bitter Creek Flume are greater than 0.007 m3 /s (0.25 cfs) for an additional 10 years (USFWS, 2018).

Recovery Actions:

- The actions needed to meet recovery criteria are organized below into six categories that are ranked in order of urgency: 1) ensure adequate water quantity, 2) protect and improve water quality, 3) protect and restore surface habitat, 4) design a long term monitoring strategy that will then become the post delisting monitoring plan, and 5) establish emergency captive rearing programs. These rankings are primarily based on our assessment of the scope, magnitude, and imminence of the threats impacting the four invertebrate species. Actions that address threats of higher magnitude and scope are considered more urgent compared to other actions. While this ranking will guide where we proactively focus our attention in the recovery process, it does not imply that these actions are restricted to being completed in this particular order. For example, 51 opportunities to address lower priority tasks will be considered if they arise before higher priority actions are completed (USFWS, 2018).

Conservation Measures and Best Management Practices:

- Develop a recovery plan for these species. The State of New Mexico has a recovery plan that has helped guide conservation efforts; however, a recovery plan with measurable objectives and criteria needs to be developed by the Service to provide delisting goals (USFWS, 2010).
- Continue investigation of Noel's amphipod population genetics to determine the species' status on the Refuge (USFWS, 2010).
- Continue investigation of the effects of fire on the Pecos assiminea to determine methods of burning an occupied area while protecting the population (USFWS, 2010).
- Secure conservation on additional lands surrounding occupied habitat to protect water quality and improve land management practices (USFWS, 2010).
- Continue to manage Refuge lands to reduce invasive plants (USFWS, 2010).

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SPECIES ACCOUNT: *Pyrgulopsis texana* (Phantom Springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/08/2013; Southwest Region (R2) (USFWS, 2016)

Physical Description

A very small aquatic snail, measuring only 0.98 to 1.27 millimeters (mm) (0.04 to 0.05 inches (in)) long (Dundee and Dundee 1969, p. 207) (USFWS, 2013).

Taxonomy

The Phantom springsnail was first described by Pilsbry (1935, pp. 91–92) as Cochliopa texana. Until 2010, the species was classified in the genus Cochliopa (Dundee and Dundee 1969, p. 209; Taylor 1987, p. 40). Hershler et al. (2010, pp. 247–250) reviewed the systematics of the species and transferred Phantom springsnail to the genus Pyrgulopsis after morphological and mitochondrial DNA analysis (USFWS, 2013).

Historical Range

See current range. The geographic extent of the historic range for the Phantom springsnail was likely not larger than the present range, but the species may have occurred in additional small springs contained within the current range of the San Solomon Spring system, such as Saragosa and Toyah Springs (USFWS, 2013).

Current Range

occurs only in the four remaining desert spring outflow channels associated with the San Solomon Spring system (San Solomon, Phantom, Giffin, and East Sandia springs) (USFWS, 2013).

Critical Habitat Designated

Yes; 7/9/2013.

Legal Description

On July 9, 2013, the U.S. Fish and Wildlife Service designated critical habitat for Phantom springsnail (Pyrgulopsis texana) under the Endangered Species Act of 1973, as amended (78 FR 40970 - 40996). The critical habitat designation includes 4 critical habitat units, which encompass 3.7 acres (9.2 hectares) in Reeves and Jeff Davis counties, Texas. All units were occupied at the time of designation (USFWS, 2013).

Critical Habitat Designation

Four areas are designated as critical habitat for Pyrgulopsis texana (1) San Solomon Spring; (2) Giffin Spring; (3) East Sandia Spring; (4) Phantom Lake Spring.

San Solomon Spring Unit. The San Solomon Spring Unit consists of 1.8 ha (4.4 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. It is located in Reeves County, near Balmorhea, Texas. San Solomon Spring provides the water for the large swimming pool at Balmorhea State Park, which is owned and managed by the Texas Parks and Wildlife Department. The designation includes all springs, seeps, and outflows of San Solomon Spring, including the part of the concrete-lined pool that has a natural substrate bottom and irrigation ditch, and two constructed cie´negas. While the ditches do not provide all of the physical or biological features (such as submerged vegetation), there are sufficient features (including natural substrates on the ditch bottoms) to provide for the life-history processes of the species. Habitat in this unit is threatened by future declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, and the introduction of other nonnative species. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Giffin Spring Unit. The Giffin Spring Unit consists of 0.7 ha (1.7 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. It is located on private property in Reeves County, near Balmorhea, Texas, and its waters are captured in irrigation earthen channels for agricultural use. The designation includes all springs, seeps, sinkholes, and outflows of Giffin Spring. The unit contains most all of the identified physical or biological features essential to the conservation of the species. Habitat in this unit is threatened by declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, the introduction of other nonnative species, and further modification of spring outflow channels. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

East Sandia Spring Unit. East Sandia Spring consists of 1.2 ha (3.0 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. This unit is included within a preserve owned and managed by The Nature Conservancy (Karges 2003, p. 145) in Reeves County just east of Balmorhea, Texas. The designation includes the springhead itself and surrounding seeps and outflows. The unit contains all of the identified physical or biological features essential to the conservation of the species. Habitat in this unit is threatened by declining spring flows due to drought or groundwater withdrawals, the introduction of nonnative species, and modification of spring outflow channels. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Phantom Lake Spring Unit. Phantom Lake Spring consists of a small pool about 0.02 ha (0.05 ac) in size that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains the features essential to the conservation of these species. Phantom Lake Spring is owned by the U.S. Bureau of Reclamation about 6 km (4 mi) west of Balmorhea State Park in Jeff Davis County, Texas. The designation includes only the springhead pool. The physical or biological features of the habitat at Phantom Lake Spring have been maintained since 2000 by a pumping system and subsequent reconstruction of the spring pool. Although artificially maintained, the site continues to provide sufficient physical or biological features to provide for all the life-history processes of the three invertebrate species. Habitat in this unit is threatened by future declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, and the introduction of other nonnative species. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Jeff Davis County and Reeves County, Texas. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of Phantom springsnail and Phantom tryonia are springs and spring-fed aquatic systems that contain:

(i) Permanent, flowing, unpolluted water (free from contamination) emerging from the ground and flowing on the surface;

(ii) Water temperatures that vary between 11 and 27 °C (52 to 81 °F) with natural seasonal and diurnal variations slightly above and below that range;

(iii) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for breeding, egg laying, maturing, feeding, and escape from predators;

(iv) Abundant food, consisting of algae, bacteria, decaying organic material, and submergent vegetation that contributes the necessary nutrients, detritus, and bacteria on which these species forage; and

(v) Either an absence of nonnative predators and competitors or nonnative predators and competitors at low population levels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, well pads, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on August 8, 2013.

The features essential to the conservation of the Phantom springsnail may require special management considerations or protection to reduce threats, such as reducing or eliminating water in suitable or occupied habitat through drought or groundwater pumping; introducing pollutants to levels unsuitable for the species; and introducing nonnative species into the inhabited spring systems such that suitable habitat is reduced or eliminated. Management activities that could ameliorate these threats include management of groundwater levels to ensure the springs remain flowing (all spring sites), managing oil and gas activities to eliminate the threat of groundwater or surface water contamination (Diamond Y Spring), maintaining the pump within Phantom Lake Spring to ensure consistent flow, managing existing nonnative species, red-rim melania, quilted melania, and feral hogs (San Solomon, Giffin, Phantom Lake, and Diamond Y Springs), and preventing the introduction of additional nonnative species (all spring sites).

Life History

Feeding Narrative

Adult: All of these snails are presumably fine-particle feeders on detritus (organic material from decomposing organisms) and periphyton (mixture of algae and other microbes attached to submerged surfaces) associated with the substrates (mud, rocks, and vegetation) (Allan 1995, p. 83; Hershler and Sada 2002, p. 256; Lysne et al. 2007, p. 649). Dundee and Dundee (1969, p. 207) found diatoms (a group of single-celled algae) to be the primary component in the digestive tract, indicating they are a primary food source (USFWS, 2013).

Reproduction Narrative

Adult: The lifespan of most aquatic snails is thought to be 9 to 15 months (Taylor 1985, p. 16; Pennak 1989, p. 552) (USFWS, 2013). These type of snails (snails in the former family Hydrobiidae) typically reproduce several times during the spring to fall breeding season (Brown 1991, p. 292) and are sexually dimorphic (males and females are shaped differently), with females being characteristically larger and longer-lived than males (USFWS, 2013).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: Inhabits artesian spring, localized around the area where the stream issues from the cave and for about 100 feet downstream. The stream contains a few patches of CHARA and the bottom contains much debris over which alga has grown. The water temperature runs in the 70's F, varying with high flow and low flow and has a high mineral content (Dundee, 1969). The lacustrine shallow water habitat where this species was once found has now dried up. This species is concentrated near the sources of the three known springs and typically found on hard substrates where it is often extremely abundant (Hershler et al., 2010). Benthic (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 2013)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2013)

Dispersal

Adult: Low (USFWS, 2013)

Immigration/Emigration

Adult: Unlikely (USFWS, 2013)

Dispersal/Migration Narrative

Adult: Because of their small size and dependence on water, significant dispersal (in other words, movement between spring systems) does not likely occur, although on rare occasions aquatic snails have been transported by becoming attached to the feathers and feet of migratory birds (Roscoe 1955, p. 66; Dundee et al. 1967, pp. 89–90). In general, the species have little capacity to move beyond their isolated aquatic environments (USFWS, 2013).

Population Information and Trends

Population Trends:

Long-term decline of <30% to increase of 25% (NatureServe, 2015)

Resiliency:

Low (inferred from NatureServe, 2015)

Representation:

Low (inferred from NatureServe, 2015)

Redundancy:

Low (inferred from NatureServe, 2015)

Population Growth Rate:

Very healthy population in 1935 and 1968 (Dundee and Dundee, 1969). Decline of <30% to increase of 25% (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

>1,000,000 individuals (NatureServe, 2015)

Population Narrative:

Very healthy population in 1935 and 1968 (Dundee and Dundee, 1969). Decline of <30% to increase of 25% This species is concentrated near the sources of the three known springs and is often extremely abundant (Hershler et al., 2010). Restricted to Phantom Lake Spring, Phantom Cave, Texas (Dundee and Dundee, 1969). Localized around the area where the stream issues from the cave and, at one time, for perhaps 100 feet downstream, but now only at immediate outflow area (USFWS, 2003). Hershler et al. (2010) restricted the distribution to three springs in the vicinity of Balmorhe, Texas; primarily concentrated near the source of each (NatureServe, 2015). Low resiliency, representation and redundancy are inferred based on the low number of known populations and the limited geography in which the species is found.

Threats and Stressors

Stressor: Groundwater level decline (USFWS, 2013)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: The primary threat to the continued existence of the San Solomon Spring species is the degradation and potential future loss of aquatic habitat (flowing water from the spring outlets) due to the decline of groundwater levels in the aquifers that support spring surface flows. Habitat for these species is exclusively aquatic and completely dependent on spring flows

emerging to the surface from underground aquifer sources. Spring flows throughout the San Solomon Spring system have and continue to decline in flow rate, and as spring flow declines, available aquatic habitat is reduced and altered. If one spring ceases to flow continually, all habitats for the Phantom springsnail, Phantom tryonia, and diminutive amphipod are lost, and the populations will be extirpated. If all of the springs lose consistent surface flows, all natural habitats for these aquatic invertebrates will be gone, and the species will become extinct.

Recovery

Recovery Actions:

- No recovery plan has been written for this species.

References

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Determination of Endangered Species Status for Six West Texas Aquatic Invertebrates.

SPECIES ACCOUNT: *Pyrgulopsis trivialis* (Three Forks Springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; April 17, 2012 (77 FR 23060).

Physical Description

Three Forks springsnail is a small, underwater snail; it is 1.5 to 4.5 millimeters (0.05 to 0.18 inch [in.]) in height and has an ovate to narrowly conic shell with 3.4 to 5.0 whorls. The periostracum, a layer of chitin surrounding the outer shell, is tan; the snout and tentacles are dark brown; and the head/foot is a lighter brown. The operculum, a door-like flap that is closed by the withdrawal of the head/foot, is amber in color. Females are typically larger than males (77 FR 23060; NatureServe 2015; USFWS 2012a).

Taxonomy

The Three Forks springsnail was originally described as Fontelicella trivialis and then as Pyrgulopsis confluentis. The species was renamed Pyrgulopsis trivialis in 1994, and this is recognized to be a valid taxon by the U.S. Fish and Wildlife Service (77 FR 23060).

Historical Range

The Three Forks springsnail was historically distributed in three separate spring complexes—Three Forks Springs, Boneyard Bog Springs, and Boneyard Creek Springs—in the North Fork East Fork Black River Watershed of the White Mountains in Apache County, east-central Arizona. It is locally endemic to the Three Forks and Boneyard spring complexes (77 FR 23060; NatureServe 2015; USFWS 2012a).

Current Range

Currently, the Three Forks springsnail is found only in the Boneyard Bog Springs complex and the Boneyard Creek Springs complex in east-central Arizona, having been extirpated from Three Forks Springs (77 FR 23060; NatureServe 2015; USFWS 2012a).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 4/17/2012.

Legal Description

On April 17, 2012, the U.S. Fish and Wildlife Service designated critical habitat for Pyrgulopsis trivialis.

Critical Habitat Designation

Critical habitat for the Three Forks Springsnail is designated in two areas currently occupied, and one area currently unoccupied by the species, but considered to have been historically occupied.

Three Forks Springs Unit. The Three Forks Springs Unit is a complex of springs, spring runs, spring seeps, a segment of an unnamed stream connecting them, and a small amount of upland area encircling them to make a single, contiguous unit of approximately 6.1 ac (2.5 ha) in the vicinity of UTM Zone 12 coordinate 655710, 3747260 in Apache County, Arizona. The entire unit is in Federal ownership and managed by the Apache-Sitgreaves National Forests. The unit encompasses eight major springheads and spring runs, each flowing a short distance of several meters to an unnamed tributary of the Black River. Two of the spring runs flow into a shallow pond and has an outflow run to the unnamed tributary. The springs complex contains spring seeps along the spring runs and the tributary. The tributary itself provides habitat connectivity. The area within the designated unit contains a small amount of upland area adjacent to the springheads, spring runs, spring seeps, and the tributary segment. The moist soils and vegetation in the adjacent uplands (approximately 3.3 ft (1.0 m) from surface water) produce periphyton (food for snails) and protect the substrate. Currently, the Three Forks Springs Unit is not occupied. However, the Three Forks Springs' first documented occupancy was in 1973 (Landye 1973, p. 49), and the species was abundant here until 2004 (AGFD 2008, entire), at which time the waters are suspected to have been contaminated by wildfire retardant drift. The last documented occurrence of the Three Forks springsnail at Three Forks Springs was in 2003 (AGFD 2008, entire). Fire retardant becomes nontoxic within a few days of contact with water, so currently, the Three Forks Springs Unit contains all of the PCEs. The unit is essential for the conservation of the species, because: (1) It has the ability to support all of the Three Forks springsnail life processes, (2) the geographic area occupied at the time of this final listing rule is not sufficient for recovery, and (3) it increases the species' population redundancy. There are only two currently occupied areas representing a portion of the species' former range, and these two small areas cause the species to be vulnerable to extinction from a single, catastrophic event. Threats to the Three Forks springsnail in this unit include the soil erosion following wildfires, fire retardant chemicals, drought, nonnative crayfish, and potential introduction of nonnative New Zealand mudsnails.

Boneyard Bog Springs Unit. The Boneyard Bog Springs Unit is a complex of springs, spring runs, spring seeps, and the segment of Boneyard Creek connecting them, and a small amount of upland area encircling them to make them a single unit of approximately 5.3 ac (2.1 ha), in the vicinity of UTM Zone 12 coordinate 659970, 3750730, in Apache County, Arizona. The entire unit is in Federal ownership and managed by the Apache-Sitgreaves National Forests. The unit encompasses eight major springheads and spring runs, each of which flows several yards (meters) to Boneyard Creek, a tributary of the Black River. The spring complex contains spring seeps along the spring runs and the tributary. The Service designated a contiguous critical habitat unit that includes the springheads, spring runs, seeps, and that portion of Boneyard Creek that connects the spring runs. Boneyard Creek is occupied where spring seeps are present along it, and the unit will provide for springsnail movement downstream, and is essential for habitat connectivity. This unit contains approximately 3.3 ft (1.0 m) in width of upland area on each side of the springheads, spring runs, spring seeps, and tributary segment, because the moist soils and vegetation in the adjacent uplands provide food for the snails. This unit is currently occupied and contains all the PBFs essential for the conservation of the species. Also, the PBFs that may require special management are adequately flowing springs, runs, and seeps that are free of contaminants and disturbance from nonnative species. Special management is needed to protect against the threats of wildfire, fire retardant used to fight wildfires, elk wallowing, predation by nonnative crayfish, drought, and potential competition from nonnative New Zealand mudsnails.

Boneyard Creek Springs Unit. The Boneyard Creek Springs Unit is a complex of springs, spring runs, spring seeps, and the segment of Boneyard Creek connecting them, and a small amount of upland area encompassing them, in a single, contiguous unit of approximately 5.8 ac (2.3 ha), in the vicinity of UTM Zone 12 coordinate 658300, 3749790, in Apache County, Arizona. The entire unit is in Federal ownership and managed by the Apache-Sitgreaves National Forests. The unit encompasses at least 11 major springheads and spring runs, which each flow a distance of several meters (yards) to Boneyard Creek, a tributary of the Black River. The spring complex contains spring seeps along the spring runs and the tributary. The Service designated as critical habitat a contiguous unit that includes the springheads, spring runs, seeps, and that portion of Boneyard Creek that connects the spring runs. Boneyard Creek is occupied where there are spring seeps along it, and it should provide for springsnail movement downstream and is essential for habitat connectivity. The area within the unit contains approximately 3.3 ft (1.0 m) in width of upland area on each side of the springheads, spring runs, spring seeps, and tributary segment. The moist soils and vegetation in the adjacent uplands produce food for the snails and protect the substrate they use. The Boneyard Creek Springs Unit is currently occupied and contains all the PBFs essential for the conservation of the species. The PBFs that may require special management are adequately flowing springs, runs, and seeps that are free of contaminants and disturbance from nonnative species. Threats to the Three Forks springsnail in this unit that may require special management include wildfire, fire retardant used to fight wildfires, predation by nonnative crayfish, drought, and potential competition from nonnative New Zealand mudsnails.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Apache County, Arizona. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the San Bernardino springsnail consist of four components:

(i) Adequately clean spring water (free from contamination) emerging from the ground and flowing on the surface;

(ii) Periphyton (attached algae), bacteria, and decaying organic material for food;

(iii) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for egglaying, maturing, feeding, and escape from predators; and

(iv) Either an absence of nonnative predators (crayfish) and competitors (snails) or their presence at low population levels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures other than concrete spring-boxes, which are included to protect the flowing water within them.

The features essential to the conservation of the Three Forks springsnail may require special management considerations or protections to reduce the following threats: Soil erosion following high-intensity wildfires, exposure to fire retardant, springhead inundation, water depletion and diversion, and the introduction of nonnative predators and competitors. Management activities that could ameliorate threats include (but are not limited to) protecting against: (1) Wildfire and fire retardant used to fight wildfires, (2) predation by nonnative crayfish, (3) water depletion and diversion, (4) potential competition from nonnative New Zealand mudsnails or predation by nonnative crayfish, and (5) harm from livestock and other ungulates through fencing to protect spring habitats from damage. Special management is also needed for the purposes of adaptive management, and includes continuing to conduct research on the springsnails, and on critical aspects of their biology (for example, reproduction, sources of mortality, sensitivity to contaminants, dispersal behavior, anti-predator behavior, etc.).

Life History

Feeding Narrative

Adult: The Three Forks springsnail is a detritivore and a benthic grazer. The diet of the Three Forks springsnail is widely distributed and consists of periphyton (attached algae), detritus, bacteria, and other microbes that live in aquatic environments and make this springsnail species a semi-specialist feeder. Three Forks springsnails graze and eat off of a firm substrate such as cobble, gravel, or woody debris. Currently, the Three Forks springsnail has no competitors for food resources; however, the threat exists that invasive species such as the New Zealand mudsnail (Potamopyrgus antipodarum) may compete for food resources in the future (77 FR 23060; NatureServe 2015; USFWS 2012a).

Reproduction Narrative

Adult: The Three Forks springsnail lays a single small egg capsule on a firm substrate such as cobble, gravel, or woody debris. The Three Forks springsnail has low parental investment; however, the larval stage of the Three Forks springsnail is completed in the egg capsule. Upon hatching, tiny snails emerge into their adult habitat, and no parental care is provided. The lifespan of most aquatic snails is 9 to 15 months. The survival of one species in the genus Pyrgulopsis in a laboratory setting was nearly 13 months (77 FR 23060; NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Habitat destruction limits the distribution of the Three Forks springsnail.

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist

Tolerance Ranges/Thresholds

Adult: Low; Three Forks springsnails are sensitive to water quality and are found within relatively narrow habitat parameters (77 FR 23060).

Habitat Narrative

Adult: Three Forks springsnails are found in creeks or ponds, at elevations of about 3,000 m (8,200 ft.) and at temperatures of 15 to 17°C (59 to 63°F). Three Forks springsnail are clumped in freshwater rheocrene (emerging from the ground as a flowing stream) springs, seeps, spring pools, outflows, and diverse flowing waters associated with gravel, pebble, and cobble substrates, and are rarely found in mud or soft sediments. Three Forks springsnails have a narrow environmental specificity and occur in close proximity to springheads where water emerges from the ground. Springheads play a key role in the life history of springsnails; Three Forks springsnails have a decreased abundance farther away from spring vents, because they need a habitat with stable water chemistry and flow provided by spring waters. Substrate, dissolved carbon dioxide, dissolved oxygen, temperature, conductivity, pH, and water depth have also been shown to influence the distribution and abundance of the Three Forks springsnail. Dissolved salts such as calcium carbonate are also important factors for the Three Forks springsnail, because they are essential for shell formation (77 FR 23060; NatureServe 2015; USFWS 2012a).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Three forks springsnails have been known to disperse by becoming attached to the feathers of migratory birds (77 FR 23060).

Immigration/Emigration

Adult: Unlikely

Dependency on Other Individuals or Species for Dispersal

Adult: Yes; migratory birds (see dispersal).

Dispersal/Migration Narrative

Adult: The Three Forks springsnail is nonmigratory and has low mobility. They are unlikely to immigrate or emigrate, but have been known to disperse by attaching themselves to the feathers of migratory birds (77 FR 23060; NatureServe 2015).

Population Information and Trends

Population Trends:

Decreasing (short-term decline of 70 to 80 percent and long-term decline of 10 to 70 percent) (NatureServe 2015).

Species Trends:

Decreasing

Resiliency:

Low

Representation:

Low

Redundancy:

Low

Population Growth Rate:

Rapid decline.

Number of Populations:

One to five (NatureServe 2015).

Population Size:

10,000 to 1,000,000 individuals (NatureServe 2015).

Resistance to Disease:

Moderate

Adaptability:

Low

Population Narrative:

This species is restricted to a single spring complex (the North Fork of the East Fork of the Black River in Three Forks Spring and Boneyard Spring), consisting of approximately four spring sources in a 0.4-hectare (1-acre) area. The population is declining, showing a short-term decrease of 70 to 80 percent and a long-term decrease of 10 to 90 percent, and including extirpation from at least two concrete-boxed springheads at Three Forks Springs. Based on estimates from 2002, the total population is between 100,000 and 1,000,000 individuals (tens of thousands of individual snails). The Three Forks springsnail no longer occurs in abundance at Three Forks Springs. Since 2004, annual surveys at Three Forks have detected very low numbers of the species, including two individuals found in August 2005 and three individuals found in July 2008. The species continues to be abundant at Boneyard Bog Springs (NatureServe 2015).The snail is abundant where it occurs, but very restricted geographically. At the Three Forks locality, the species was found in abundance when originally described and was subsequently found in springs and spring-fed creeks over an area of only about 0.1 square kilometer (0.3 square mile). Three Forks springsnails have narrow environmental specificity and are clumped in certain areas and a small number of populations; because of this, they have low adaptability, redundancy, and representation rate, and a moderate resiliency rate. The Three Forks springsnail is thought to be somewhat resilient to low-moderate wildfires (77 FR 23060; NatureServe 2015).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Habitat is destroyed by humans, ungulates, or other wildlife.
Response: Reduced habitat, habitat degradation.
Consequence: Decreased population numbers, extirpation.
Narrative: The Three Forks springsnail has restricted distribution, and the greatest threat to this species is habitat loss. Throughout the 20th century, Three Forks and Boneyard Springs have been affected by livestock grazing, which has degraded the aquatic environment and has been implicated in the extirpation of some smaller Three Forks springsnail populations. In the late 1990s, livestock were fenced out of the immediate areas containing the spring complexes; however, trespassing livestock may be a threat to Three Forks springsnail sites. The degradation of spring banks due to excessive livestock trampling and crayfish burrowing contributes to accelerated sedimentation and high turbidity; which in turn result in changes to habitat conditions, such as shifts in the substrate composition (77 FR 23060; NatureServe 2015).

Stressor: Wildfires
Exposure: Wildfires
Response: Mortality, illness, toxin exposure, reduction in habitat.
Consequence: Decreased population density, extirpation.
Narrative: During the early 1900s, fires were suppressed, and changes in the fuel load altered forest structure and the natural fire regime by building up woody fuels that led to very hot, intense fires. Since then, lands around Three Forks springsnail habitats have been burned by big wildfires, and studies have shown that there are lower springsnail densities following wildfires. The lack of vegetation and forest litter following intense fires can expose soils to surface erosion during storms, causing erosion in downstream drainages. This can cause infilling of substrates and shifts in water chemistry in spring systems. Areas around Boneyard Bog Springs and Boneyard Creek Springs were burned by the Wallow Fire in 2011, and these occupied springs are at risk from ash and sediment erosion during anticipated stormwater flows.Fire suppression such as aerial fire retardants are toxic to springsnails. Some fire retardant chemicals are ammonia-based, and many contain sodium ferrocyanaid, which is toxic to fish and aquatic invertebrates. Contamination of aquatic sites can occur via direct application, wind drift, or runoff from treated uplands. It is thought that the Three Forked springsnail was extirpated from Three Forks Springs in 2004 mostly due to the heavy use of fire retardants. There is the potential for future wildfires to occur near the Boneyard Bog Springs and Boneyard Creek Springs sites (77 FR 23060; NatureServe 2015.)

Stressor: Ungulates
Exposure: Livestock grazing, elk wallowing.
Response: Habitat degradation.
Consequence: Decreased population numbers.
Narrative: As stated in the above habitat destruction section, livestock grazing degraded the aquatic environment by reducing banks to mud with sparse grass. In addition, elk wallowing prevents spring seepage from developing into free-flowing spring runs. Although elk wallowing does not have a huge impact on the Three Forks springsnail on its own, it may, in combination with the other threats, be contributing to the species' risk of extinction (77 FR 23060; NatureServe 2015).

Stressor: Nonnative species
Exposure: Introduction of nonnative species.
Response: Illness, mortality, predation.
Consequence: Reduction in quality habitat, reduction in population numbers.
Narrative: Springsnails are vulnerable to predation by a variety of fish, amphibians, reptiles, mammals, and macroinvertebrates. Nonnative crayfish are known predators of aquatic snails, and crayfish burrowing causes poor quality habitat for Three Forks springsnails. Prior to extirpation in the Three Forks Springs, Three Forks springsnails were no longer being found in concrete-boxed springheads where they had previously been observed in abundance. This was due to the predation of nonnative crayfish.Nonnative species such as the New Zealand mudsnail (Potamopyrgus antipodarum) can pose a threat to Three Forks springsnail, because they can out compete Three Forks springsnail for resources. The mudsnail can be easily transported into new environments and unintentionally introduced via birds, hikers, researchers, and resource managers. The New Zealand mudsnail can out-compete and replace native springsnails, because they tolerate a wide range of habitats and can reach densities exceeding tens of thousands per square meter. They can also consume nearly all microorganisms attached to submerged

substrates, making food no longer available for native species such as springsnails. Additionally, control would be difficult, because mudsnails are small and chemical treatment to eradicate them would also eradicate Three Forks springsnails. As New Zealand mudsnails move farther into the Three Forks springsnail habitat they pose more of a threat (77 FR 23060; NatureServe 2015).

Recovery

Reclassification Criteria:
Need to develop a recovery plan and reclassification criteria.

Delisting Criteria:
Need to develop a recovery plan and delisting criteria.

Recovery Actions:
- Need to develop a recovery plan.

Conservation Measures and Best Management Practices:
-

Additional Threshold Information:
-
-

References

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SPECIES ACCOUNT: *Samoana fragilis* (Fragile tree snail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/02/2015; Pacific Region (R1) (USFWS, 2016)

Physical Description

The conical shell of this snail is 0.5 to 0.6 inches (in) (12 to 16 millimeters (mm)) long, 0.4 to 0.5 in (10 to 12 mm) wide, and is formed by four whorls that spiral to the right. The common name is derived from the thin, semi-transparent nature of the shell. The shell has delicate spiral striations intersected by transverse growth striations. The background color is buff, tinted by narrow darker maculations and whitish banding that are derived from the internal organs of the animal that are visible through the shell (Crampton 1925).

Taxonomy

The genus Samoana is represented in the Mariana Islands by a single species, the fragile tree snail (Samoana fragilis). The fragile tree snail was first collected on Guam in 1819 by Quoy and Gaimard during the Freycinet Uranie expedition of 1817 to 1819 (Crampton 1925). Cramptons 1925 taxonomic work for this species is the most recent and accepted taxonomy for this species.

Historical Range

The fragile tree snail has been reported from the islands of Guam and Rota. In 1920, Crampton (1925) documented fragile tree snails from 13 sites on Guam. Kondo (1970) documented the 1959 discovery of the fragile tree snail on Rota by R.P. Owen. A previous island survey in 1952 (Kondo 1970) did not find this species.

Current Range

In 1989, Hopper and Smith (1992) resurveyed Cramptons original sites plus several more, all on Guam. At that time, they found fragile tree snails at only six sites. The most recent survey on Guam for the fragile tree snail was conducted on February 26, 2008 and between May 21 and August 30, 2008. Only one colony was found to have the fragile tree snail at Pugua Point Colony (Smith et. al., 2009). The original site where this species was found on Rota is mostly agricultural fields and no living snails were found there in 1995 (Bauman 1996). In 1996, a new site was found in a different area (Bauman 1996).

Distinct Population Segments Defined

No.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: The snails are generally nocturnal, live on bushes or trees, and feed on decaying plant material.

Reproduction Narrative

Adult: The fragile tree snail exhibits two reproductive characteristics, which are unique among the Mariana Islands partulid snails. Adults attain sexual maturity before reaching maximum shell size and produce relatively large eggs (0.13 to 0.16 in (3.3 to 4.3 mm)) that are encapsulated in a tough, calcareous shell (Crampton 1925). These egg shells are reabsorbed and the snail gives birth to live young. In general, partulid snails begin reproducing in less than 12 months and may live up to 5 years. Up to 18 young are produced each year.

Spatial Arrangements of the Population

Adult: clumped according to suitable habitat

Tolerance Ranges/Thresholds

Adult: unknown

Habitat Narrative

Adult: Partulid tree snails prefer cool, shaded forest habitats (Crampton 1925; Cowie 1992; Smith 1995) with high humidity and reduced air movement that might otherwise promote excessive water loss. Crampton (1925) described the habitat requirements of the partulid tree snails of the Mariana Islands as having sufficiently high and dense growth to provide shade, to conserve moisture, and to effect the production of a rich humus. Hence the limits to the areas occupied by Partulidae are set by the more ultimate ecological conditions which determine the distribution of suitable vegetation. Crampton (1925) further described the intact structure of native Mariana forests as having four general levels: high trees; shrubs and Pandanus spp.; cycads and taller ferns; and succulent herbs. He noted that the Mariana Islands partulid tree snails preferentially live on subcanopy vegetation and do not use the high canopy trees.

Dispersal/Migration

Motility/Mobility

Adult: low

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory

Dispersal

Adult: low

Immigration/Emigration

Adult: unlikely because of fragmented habitat

Dependency on Other Individuals or Species for Dispersal

Adult: not applicable

Dispersal/Migration Narrative

Adult: There is not a lot of information regarding the dispersal of this species

Population Information and Trends

Population Trends:

Declining

Species Trends:
Declining

Resiliency:
low

Representation:
low

Redundancy:
low

Population Growth Rate:
Unknown

Number of Populations:
1

Population Size:
unknown

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
There are no quantitative estimates for the fragile tree snail (Bauman 1996) but Crampton (1925) described this species as rare. In a 2011 survey of Anderson Air Force Base (AAFB), a single colony of the fragile tree snail was found (Janeke, in litt. 2011).

Threats and Stressors

Stressor: Habitat Destruction and Degradation
Exposure:
Response:
Consequence:
Narrative: Following World War II, open agricultural fields and other areas prone to erosion on Guam were seeded with Leucaena leucocephala (tangantangan), small trees which grow as single species stands with no substantial understory. The microclimatic condition in such areas is dry with little accumulation of leaf litter humus, and is particularly unsuitable as partulid tree snail

habitat (Hopper and Smith 1992). In addition, native forest cannot reinvade and grow where this alien weed has become established (Hopper and Smith 1992; Amidon 2007, pers. comm.).

Stressor: Natural Events
Exposure:
Response:
Consequence:
Narrative: Typhoons are a common occurrence in the Mariana Islands and have impacted the remaining forests on these islands. The island of Guam, for example, has been affected by typhoons in 37 of the last 50 years (Naval Pacific Meterology and Oceanography Center Joint Typhoon Warning Center (JTWC) 2007). During the 1990s Guam experienced 20 typhoons, and supertyphoons (having gusts exceeding 150 miles per hour (mph) (240 kilometers per hour (kph))) occur with regularity (about once every 5 to 10 years). There is some evidence that the frequency of severe storms (estimated gusts exceeding 100 mph (160 kph) is increasing in the Mariana Islands. The historical record for Guam shows increasing numbers of mild (estimated gusts in the range of 50 to 100 mph (80 to 160 kph)) and severe storms over the last three centuries, as well as in just the last decade (JTWC 2007). These storms have been known to defoliate forested areas and down trees, which can impact tree snail populations. For example, in August 2004, Typhoon Chaba stalled 25 mi (40 km) north of Rota for several hours, downing trees and defoliating large sections of the forested areas, especially on the windward side of the island (JTWC 2007). Vegetation changes associated with this storm have opened up forested areas that were excellent habitat for partulid tree snails. These open forests suffer from changes in microhabitat, such as desiccation, that make the continued survival of snails unlikely. These changes continue to occur today with each successive typhoon (Amidon 2005, pers. comm.).

Stressor: Feral ungulates
Exposure:
Response:
Consequence:
Narrative: The structure of the limestone forest on Guam and Rota is slowly changing due to the presence of Philippine deer (Cervus mariannus) (Guam and Rota), feral pigs (Sus scrofra) (Guam), water buffalo (Bubalus bubalis) (Guam), and cattle (Bos taurus) (Rota), as they browse on seeds and seedlings, retarding regeneration of the forest plants (Wiles et al. 1999). These ungulates have caused severe damage to native forest vegetation by browsing directly on plants, causing erosion (Marshall et al. 1995; Kessler 1997), and retarding forest growth and regeneration (Lemke 1992). This in turn reduces the quantity and quality of forested habitat for the fragile tree snail.

Stressor: Military Activity
Exposure:
Response:
Consequence:
Narrative: Smith et.al. 2009, described the Naval Computer and Telecommunications Station at Finegayan on Guam as having an understory that had been severely damaged by feral ungulates. The removal of the understory trees and shrubs has allowed for greater air motion and resulting desiccation makes the conditions unsuitable for the survival of land snails.

Stressor: Invasive predators

Exposure:
Response:
Consequence:
Narrative: Predation by the alien rosy carnivore snail (Euglandina rosea) and the alien Manokwar flatworm (Platydemis manokwari) is a serious threat to the survival of the fragile tree snail. The predatory rosy carnivore snail is native to the southeastern United States and was introduced into the Mariana Islands, including Rota, and Guam, in 1957 (Eldredge 1988). Since being introduced, this voracious predator of snails has been dispersed by humans throughout the main islands. The rosy carnivore snail was imported to these and other Pacific islands as a biological control agent for another alien snail, the giant African snail (Achatina fulica), which is an agricultural pest. However, while its effectiveness as a biological control agent against the giant African snail is questionable (Mead 1961; Tillier and Clarke 1983; Christiansen 1984), field observations have established that the rosy carnivore snail will readily feed on native Pacific island tree snails, including the Partulidae (Tillier and Clarke 1983; Murray et al. 1988; Miller 1993) and the Hawaiian achatinellid tree snails (Hadfield et al. 1993). A study of the diet of the rosy carnivore snail on the island of Mauritius in the Indian Ocean showed that this alien predator preferred native snails over the targeted alien giant African snail (Griffiths et al. 1993). On some or all of these tropical islands, the rosy carnivore snail has expanded its normal terrestrial feeding behavior to include native snails found in arboreal habitats (Murray et al. 1988; Hadfield et al. 1993; Miller 1993). The rosy carnivore snail has caused the extinction of many populations and species of native snails throughout the Pacific islands (Tillier and Clarke 1983; Murray et al. 1988; Hopper and Smith 1992; Hadfield et al. 1993; Miller 1993). Predation on native partulid tree snails by the terrestrial Manokwar flatworm is also a threat to the long-term survival of these snails. This voracious snail predator was introduced into Guam in 1978 and has been spread by humans throughout the main Mariana Islands, including Rota (Eldredge 1988). It has proven to be an effective biological control agent for the giant African snail but it has also contributed to the decline of native tree snails, in part due to its ability to ascend into trees and bushes that support native snails. Areas with populations of the flatworm usually lack partulid tree snails or have declining numbers of snails (Hopper and Smith 1992). It is suggested that rats (Rattus spp.) are the invasive animal likely responsible for the greatest number of animal extinctions on islands, including extinctions of snail species (Towns et al. 2006, p. 88). In the Hawaiian Islands, rats are known to prey upon endemic arboreal snails and are a serious and ongoing threat to the long-term survival of all endemic tree snails (Hadfield et al. 1993, p. 621). In the Mariana Islands, predation by rats is a threat to the long-term survival of partulid tree snails because predation by rats has been observed on Partula spp. and rats occur on Guam (Sischo, in litt. 2011).

Stressor: Inadequate Regulations
Exposure:
Response:
Consequence:
Narrative: The fragile tree snail currently receives no protection under the federal Endangered Species Act (16 U.S.C. §1531-1544). It also does not receive protection under the CNMI Endangered Species List (Public Law 2-51 CMC 5108b), but does receive protection under the Guam Endangered Species Act (5GCA § 63205(c)).

Stressor: Fragmented/Isolated Populations
Exposure:

Response:
Consequence:
Narrative: Even if the threats responsible for the decline of this species were controlled, the persistence of existing populations is hampered by the small number of extant populations and the small geographic range of the known populations. These circumstances make the species more vulnerable to extinction due to a variety of natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Pimm et al. 1988; Center for Conservation Biology 1994; Mangel and Tier 1994). Randomly occurring natural events such as typhoons and droughts could eliminate one or more of the five remaining populations of the fragile tree snail. This is especially true due to several life-history features of this and all other partulid tree snails (Cowie 1992): reproductive rates are low; eggs are not laid as in most terrestrial snails, but the young are born live; dispersal is very limited with most individuals remaining in the tree or bush in which they were born. All of these traits make these snails very sensitive to any random event that could lead to a reduction or loss of reproductive individuals.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:
- Conduct surveys for fragile tree snails
- Develop and implement nonnative predatory snail removal and control program
- Develop and implement nonnative flatworm removal and control program
- Conduct ungulate (deer, pigs, water buffalo, and cattle) removal and control
- Conduct habitat restoration
- Restore the native understory

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2013

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2015

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U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 06/01/2019

SPECIES ACCOUNT: *Succinea chittenangoensis* (Chittenango ovate amber snail)

Species Taxonomic and Listing Information

Commonly-used Acronym: COAS

Listing Status: Threatened; Northeast Region (R5) (USFWS, 2015). Recommend Uplist to Endangered (USFWS, 2019).

Physical Description

The shell of Novisuccinea chittenangoensis is ovate, slender, acute, and of moderate thickness (Figure 3a). The shell suture is deep. The spire is gently convex, laterally compressed, with 3¼ whorls. The spire is long, slightly less than half the shell length, and the aperture is very oblique. The shell color is subtranslucent, calcareous pale yellow to white. The surface is somewhat glossy and marked with growth wrinkles and lines. The size varies somewhat, but adult specimens of the type lot averaged 20.9 millimeters (mm) in shell length. Various adult specimens measured during the summer of 1981 and 1982 ranged from 19 to 24 mm (Aloi and Ringler 1982). Hatchlings measure 1 to 2 mm in shell length (Molloy and Norton 1993, and Molloy 1995), and yearlings average around 10 mm (Aloi 1985). Measurements of all Novisuccinea chittenangoensis in 2002 (Arrigoni 2002) ranged from 7 to 23 mm. The base color of the living animal is very pale subtranslucent yellow. The mantle, kidney, and hepatopancreas are visible through the shell but are often slightly obscured by the thickness of the shell. The dorsal surface of the mantle is pale yellow, tinted with olive, often marked with black streaks and blotches. Over the hepatopancreas is a golden yellow tessellation that is marked with gray or black spots and streaks. A dark marking on the posterior surface of the foot (Figure 3b) is distinctive (Thomee 1986). However, the mark is not present on the hatchlings making them impossible to identify in the field. The mark is obvious when the snail reaches approximately 6 to 9 mm in length.

Taxonomy

The Chittenango ovate amber snail was originally described as a subspecies or form of the more widespread ovate amber snail S. (= N.) ovalis, and is referred to in many publications as S. ovalis chittenangoensis (Pilsbry 1908, Solem 1976). Whereas Solem (1976) considered the species as a form of N. ovalis, citing similarities in genitalia and radula between the two and attributing shell differences to, possibly, a marked genetic mutation (perhaps with dominance accounting for lack of intergradation between Novisuccinea chittenangoensis and N. ovalis). Grimm (1981) considered it a distinct species due to external morphological differences (color and shell shape). By 1981, N. ovalis could not be found at the Falls; however, during sampling for Hoagland's electrophoretic analyses, N. ovalis was found at two locations within approximately 16 kilometers of Chittenango Falls (Hoagland and Davis 1987) (USFWS, 2006).

Current Range

Only known to be extant from a single location in Chittenango State Park, New York, but known as fossil from Tennessee to Ontario and as far west as Iowa and Minnesota. Many false reports exist including most from Hubricht (1985). See USFWS (1987) and Hoagland and Davis (1987) and USFWS (2003; 2006). Specimens tentatively reported to be this species from Minnesota

(Frest, 1986) are likely a variant or subspecies of Novisuccinea ovalis (USFWS, 2003). It is apparantly restricted, therefore, to the single site in New York (USFWS, 2003; 2006).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: It is still unclear when the snails mature, although Grimm (1981) believes they reach maturity in five to eight months, or the spring following hatching. At the end of their first full year of growth, snails observed by Aloi and Ringler (1982) averaged around 10 mm. By the end of the following year, the adult snails were observed to reach a length of approximately 21 mm; they then die, completing a life span of about 2.5 years. This life span is similar to those in captive populations (Rosamond Gifford Zoo, unpublished data). Novisuccinea chittenangoensis apparently feed on microflora and must obtain high levels of calcium carbonate from their environment for proper shell formation. Thomee (1986) observed that they were generally found on green vegetation, whereas Succinea sp. B was more frequently found on dead vegetation (USFWS, 2006).

Reproduction Narrative

Adult: Lifespan of Novisuccinea chittenangoensis was 2 to 2.5 years, based on shell characters and range of sizes seen. It appeared in May, copulated in June, deposited eggs in July, suffered an abrupt dieoff, became cryptic in August, and overwintered under think ice overhangs. The highest density of Novisuccinea chittenangoensis was always near seeps; multiple regression analyses predicted highest densities in plots with blue Aster, Bidens sp., exposed wet soil, low light and no Graminae spp. Individual (modal) Novisuccinea chittenangoensis were most often seen on green, dry Eupatorium purpureum, Angelica purpurea and blue Aster. Modal microhabitat variable values for individuals were: temperature 16 C, relative humidity 100 percent, 1615 to 7535 lux, and windspeed 0. Field activity correlated positively with wet green vegetation, relative humidity >85 percent, temperature >16 C, light 1615 to 2691 1x, morning hours, and no wind. (USFWS, 2006).

Geographic or Habitat Restraints or Barriers

Adult: Wet cliffs/talus (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Species inhabits the wet cliff walls and talus in a ravine at the base of Chittenango Falls (a 167 foot waterfall). The ravine ledges comprise an early successional sere that is periodically rejuvenated to a bare substrate by floodwaters. It has also been found in the vegetation both within the saturated spray of the falls, and surrounding a nearby springfed area. The species requires a substrate rich in calcium carbonate and appears to prefer green vegetation such as the various mosses, liverworts, and other low herbaceous vegetation found within the spray zone adjacent to the falls (USFWS, 1997; 2006). (NatureServe, 2015). High ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the specific habitat needs of this species and the limited number of known locations (one).

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigrant (NatureServe, 2015)

Immigration/Emigration

Adult: No (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Nonmigrant (NatureServe, 2015). Species is only found at one site (wet cliff walls and talus near waterfall).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

250 - 1000 individuals (NatureServe, 2015)

Population Narrative:

Only a single population remains, with many local extinctions (although all are apparently subfossil). The species is therefore, subject to stachastic events due to its small population size and limited distribution (USFWS, 2006). Decline of 70-90% A first population estimate using the Schumacher-Eschmeyer method was 183 individuals in 1982. Estimated size based on capture frequencies was 206 individuals. The population was estimated to be 178 in 2003 and 690 in 2004 and slightly larger in 2005 (USFWS, 2006). Only one extant population remains (many extinct and false reports) in Chittenango Falls State Park, Madison Co., New York (USFWS, 1997; 2006). Hotopp and Pearce (2007) documented 264 specimens from nine museums from the type locality. (NatureServe, 2015)

Threats and Stressors

Stressor: Water quality (USFWS, 2006)
Exposure:
Response:
Consequence: Habitat degradation
Narrative: Changes in water quantity throughout the Chittenango watershed may alter the habitat (including parameters such as temperature, humidity, and vegetation) along the Falls and further information is also needed regarding these relationships. Water quantity and quality should be monitored along with any changes in the vegetation and Novisuccinea chittenangoensis habitat-use and population status to ensure that they do not surface as threats (USFWS, 2006).

Stressor: Predation (USFWS, 2006)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Predation by small mammals, birds, salamanders, beetles, and other invertebrates is also a potential threat, albeit at a low level (USFWS, 2006).

Stressor: Introduced snail (USFWS, 2006)
Exposure:
Response:
Consequence: Competition/hybridization
Narrative: A particularly perplexing problem that was first recognized at the Falls in 1985 is the presence of an introduced snail, Succinea sp. B, that may be competing with Novisuccinea chittenangoensis for food and/or breeding or wintering habitat. Succinea sp. B is found throughout Novisuccinea chittenangoensis' habitat at Chittenango Falls, and further information is needed about the possible effects of this (e.g., whether Succinea sp. B is suppressing the ability of the Novisuccinea chittenangoensis colony to sustain itself at viable levels). Investigations into the relationship between Novisuccinea chittenangoensis and Succinea sp. B were initiated in 2005 by ESF, the NYSDEC, and USFWS. Furthermore, Succinea sp. B has become widespread throughout the Chittenango Creek drainage basin both up- and downstream (Molloy 1995), including encroachment onto habitat that might otherwise be suitable for Novisuccinea chittenangoensis. In addition to the concerns about competition, there have been questions about whether Novisuccinea chittenangoensis and Succinea sp. B have the potential for hybridization, but recent analysis (referenced in the Taxonomy section of this plan) indicates that this is not a problem at this time (T. King, unpublished data). Initial concerns regarding

Novisuccinea chittenangoensis' genetics surfaced when the snails raised in captivity began to change morphologically. These changes, which became noticeable after five generations in captivity, included the shell becoming more rough and opaque and the sutures became less distinct. In addition, the spires were less pronounced and were angled to the side, giving the snails a rounder shape (Figures 6a, 6b). These changes could be due to environmental conditions in a captive setting, diet, gene frequencies, a pathogen, or a combination of these influences (USFWS, 2006).

Stressor: Flooding (USFWS, 2006)
Exposure:
Response:
Consequence: Loss of habitat/extinction
Narrative: Natural flood events occur and are a threat to this species single known population (USFWS, 2006).

Recovery

Reclassification Criteria:
Recovery Priority Number: 5. 3.3 Listing and Reclassification Priority Number: 2 (USFWS, 2019)

Delisting Criteria:
The population at Chittenango Falls is shown to be stable or improving for 10 years. To accomplish this, a baseline population size and distribution must be determined (USFWS, 2006).

At least two healthy captive colonies of Novisuccinea chittenangoensis are successfully established in order to: (1) provide a source for augmenting the population at Chittenango Falls or introductions to new sites, (2) buffer against extinction in the wild, and (3) provide a source of Novisuccinea chittenangoensis for various scientific experiments related to their recovery. A healthy captive population is defined as having sufficient genetic diversity and being large enough to meet population goals, which will be specified in a new protocol based in part on the results of genetics research as well as results of research into the optimal conditions for propagation of Novisuccinea chittenangoensis (USFWS, 2006).

The genetic distinctiveness of Novisuccinea chittenangoensis from other snails occupying the site is demonstrated (USFWS, 2006).

The Novisuccinea chittenangoensis population at Chittenango Falls must include at least 1000 snails with occupancy of both the lower and middle ledges. The population must be stable (or improving) for at least 10 years (USFWS, 2006).

Threats to the snail are abated as follows: a. All sites with Novisuccinea chittenangoensis are permanently protected through acquisition, conservation easement, or another form of agreement . b. Written management/monitoring plans are in place for each site. c. A sufficient understanding of habitat and biological requirements is gained to conduct management efforts. d. Novisuccinea chittenangoensis is ensured continued protection by New York State after ESA protections are removed. e. Any negative interaction between Novisuccinea chittenangoensis and Succinea sp. B or other species is controlled with minimal management intervention. f. Searches for any other potential extant populations have been completed, and the extant population at Chittenango Falls has been successfully augmented. g. Searches for potential introduction sites have been completed, the potential for introduction has been thoroughly evaluated and, if warranted, one or more additional Novisuccinea chittenangoensis populations have been successfully established (USFWS, 2006).

Monitoring of threats and effects of management practices indicate that recovery actions have led to a secure status for the species (USFWS, 2006).

Conservation Measures and Best Management Practices:

- The Services should continue to implement the Recovery Plan and Spotlight Species Action Plan (Service 2010 (USFWS, 2011).
- The Service should revise the official scientific name in the Code of Federal Regulations and ECOS (USFWS, 2011).
- A proposal to uplist the COAS to endangered should be prepared (USFWS, 2011).
- RECOMMENDATIONS FOR FUTURE ACTIONS • If possible, the NYSOPRHP should explore increasing staff presence at the Chittenango Falls to educate the public about the COAS and reduce trespass into the habitat. • The NYSOPRHP should attempt to learn more about trespasser demographics and size of groups trespassing. • The NYSOPRHP should determine what languages any signage/pamphlets should be written in. • The Service and partners should explore new outreach and funding options. • The Service and partners should continue to implement the Recovery Plan. • The Service should revise the official scientific name in the Code of Federal Regulations and ECOS (USFWS, 2019).

References

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SPECIES ACCOUNT: *Taylorconcha serpenticola* (Bliss Rapids snail)

Species Taxonomic and Listing Information

Listing Status: Threatened; Pacific Region (R1) (USFWS, 2016)

Physical Description

The Bliss Rapids snail (Taylorconcha serpenticola) has a very small ovoid/turbinate shell (approximately 0.08 to 0.16- inches long), with about 3.5 to 4.5 whorls (curls or turns in the shell). The shell is clear to white but appears to have two colors, very light tan to dark brown-red, which results in the “pale” and “orange” forms (USFWS, 2016).

Current Range

In the Recovery Plan for the Snake River snails (USFWS 1995), the Service reported that the Bliss Rapids snails’ range extends along the Snake River from Indian Cove Bridge (RKM 845.4 (RM 525.4)) to Twin Falls (RKM 982.3 (RM 610.5)) and that it likely occurred upstream of American Falls in a disjunct population where it had been reported from springs (RKM 1207 (RM 750)) (USFWS 1995, p. 10). The current documented range of extant populations is more restricted; this species has been identified from the Snake River near King Hill (RKM 878.5 (RM 546)) to below Lower Salmon Falls Dam (RKM 922 (RM 573)), and from spring tributaries as far upstream as Ellison Springs (RKM 972 (RM 604)) (Bates et al. 2009, p. 100). The “American Falls” occurrence was later discounted after multiple surveys failed to relocate the species (USFWS 2008a, pp. 5-6). There is an isolated river population that occupies a limited bypass reach (Dolman Rapids) between the Upper and Lower Salmon Falls reservoirs (Stephenson 2006, p. 6) (USFWS< 2016).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Food Habits: Herbivore (Adult), Detritivore (Adult)Considered moderately photophobic and resides on the lateral sides and undersides of rocks during daylight but will migrate to the uppermost surface of rocks at night to graze (USFWS, 1992).; (NatureServe, 2015)

Reproduction Narrative

Adult: Mainstem Snake River colonies reproduce in October - February and February - March in spring colonies. Egg laying occurs within two months of reproduction and eggs appear to hatch within one month. Adults exhibit a strong seasonal die off after reproduction (USFWS, 1992).; Appears to have an atypically broad habitat tolerance compared to other hydrobid snails and a broad geographic range as well (Frest and Johannes, 1992). Frest and Johannes (1992) note that relatively few closely related hydrobid snails are found in any river habitats.; (NatureServe, 2015). The average lifespan of the Bliss Rapids snail is about one year (USFWS, 2016).

Environmental Specificity

Adult: Unknown (Natureserve, 2015)

Habitat Narrative

Adult: Found in springs and unpolluted, unimpounded riverine habitats on stable rocky substrates. In rivers is found in areas associated with spring influences or rapids edge environments and tends to flank shorelines (USFWS, 1992; Hershler et al., 1994). The snails do not burrow, and avoid habitats with fine sediments. The Bliss Rapids snails are moderately photophobic, residing on the lateral sides and undersides of rocks during daylight and they migrate to the uppermost surfaces of rocks at night (USFWS 2009, Stockton et al. 2012). BIG RIVER; MEDIUM RIVER; SPRING/SPRING BROOKBenthic (NatureServe, 2015)

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant (NatureServe, 2015; USFWS, 2016)

Population Information and Trends

Population Trends:

Unknown (USFWS, 2016)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

10,000 to >1,000,000 individuals (NatureServe, 2015)

Population Narrative:

The species is vulnerable because it is isolated in a few sites all close together where random events could eliminate the species entirely (USFWS, 2005). Liu and Hershler (2009) assessed genetic variation in 29 samples (820 snails) from across the range and found no evidence of reduced genetic diversity attributable to segmentation of the Snake River by dams and genetic variation among portions of drainage separated by dams was not significant. It was first collected in the Snake River of south-central Idaho and recognized as a new taxon in 1959 but was noted as early as 1884 (Richards and Arrington, 2008). Hershler et al. described it in 1994 listing known distribution as the main stem Snake River and associated springs of south-central Idaho. It can be traced back to the late Pliocene Glenns ferry formation in Gooding Co., Idaho; the early Pleistocene Bruneau formation in Owyhee Co., Idaho; and the late Pleistocene and probable Holocene deposits in Gooding Co. (Hershler et al., 1994). The construction of three large dams along this portion of the Snake River during the 20th Century is thought to have fragmented a single, ancestral population into genetically isolated subunits (Liu and Hershler, 2009). It is one of the few remaining extant taxa from ancient Lake Idaho, which once was thought to have extended from the border between western Idaho and eastern Oregon upstream of Hells Canyon eastward to a point near American Falls, Idaho (Hershler et al., 1994). Decline of 70-90% Adult population at Thousand Springs Preserve is estimated in the 'low millions' (USFWS, 1992; Frest and Johannes, 1992). Liu and Hershler (2009) assessed genetic variation in 29 samples (820 snails) from across the range and found no evidence of reduced genetic diversity attributable to segmentation of the Snake River by dams and genetic variation among portions of drainage separated by dams was not significant. Historically ranged discontinuously over 204 river miles in the main stem Middle Snake River and associated springs in south-central Idaho (USFWS, 1992; Hershler et al., 1994), but recently found to occupy only a short reach (about 138 river km) of the river (USFWS, 2005). Hershler et al. (2005) lists 12 sites (total < about 50 km apart) within the Middle Snake River and a few tributaries. It was known historically from the main stem middle Snake River and associated springs between Indian Cove Bridge (Rkm 845.6) and Twin Falls (Rkm 982.5) (Hershler et al., 1994) but remnant populations remain in Idaho, inhabiting approximately an 80 km stretch of the Snake River upstream and downstream of Hagerman, Idaho in the Thousands Springs reach of the Snake River (Richards and Arrington, 2008) (NatureServe, 2015). It is difficult to estimate the density and relative abundance of Bliss Rapids snail colonies. The species is documented to reach high densities in cold-water springs and tributaries in the Hagerman reach of the middle Snake River (Stephenson and Bean 2003, pp. 12, 18; Stephenson et al. 2004, p. 24), whereas colonies in the mainstem Snake River (Stephenson and Bean 2003, p. 27; Stephenson et al. 2004, p. 24) tend to have lower densities (Richards et al. 2006, p. 37). Bliss Rapids snail densities in Banbury Springs averaged approximately 32.53 snails per square foot (350 snails per square meter) on three habitat types (vegetation, edge, and run habitat as defined by Richards et al. 2001, p. 379). Densities greater than 5,800 snails per sq m (790 snails per sq ft) have been documented at the outlet of Banbury Springs (Morgan Lake outlet) (Richards et al. 2006, p. 99). In an effort to account for the high variability in snail densities and their patchy distribution, researchers have used predictive models to give more accurate estimates of population size in a given area (Richards 2004, p. 58). In the most robust study to date, predictive models estimated between 200,000 and 240,000 Bliss Rapids snails in a study area measuring 625 sq m (58.1 square ft) in Banbury Springs, the largest known colony (Richards 2004, p. 59). Due to data limitations, this model has not been used to extrapolate population estimates to other spring complexes, tributary streams, or mainstem Snake River colonies. However, with few exceptions (i.e., Thousand Springs and Box Canyon), Bliss Rapids snail colonies in these areas are much smaller in areal extent than the colony at Banbury Springs, occupying only a few square feet (USFWS, 2016).

Threats and Stressors

Stressor: habitat modifications and deteriorating water quality (USFWS, 2016)
Exposure:
Response:
Consequence: Loss of habitat/Degradation of habitat
Narrative: Deteriorating water quality is listed as a threat to this species. The deterioration of the species' water quality is from one or more of the following: hydroelectric development, peak-loading effects from existing hydroelectric project operations, water pollution, inadequate regulatory mechanisms, and invasion of the non-native New Zealand mudsnail. Although some threats identified at the time of listing in 1992 no longer exist or have been moderated, ground water depletion and impaired water quality still threaten the Bliss Rapids snail and have increased with the growth of dairies over the aquifer system and use of groundwater for surface irrigation. In addition, there are significant uncertainties about the effects of hydropower operations and New Zealand mudsnails on the persistence of Bliss Rapids snails in riverine habitats. In the absence of the Act's protections, existing regulations are not likely to be sufficient to conserve the species (USFWS, 2016).

Recovery

Recovery Actions:

- Recovery Priority Number: 8C (USFWS, 2018)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Update/Revise Recovery Plan We continue to recommend that the Snake River Aquatic Species Recovery Plan be updated and/or revised to include new information that we have learned since the plan was completed in 1995. We also recommend that the recovery criteria within a revised Recovery Plan be updated in order to make them more objective and measureable. Monitoring While monitoring conducted by the Idaho Power Company is the only regular monitoring currently conducted, and has provided invaluable insights into the species distribution and population trends, we recommend the Service initiate a more systematic and rigorous monitoring effort at strategic locations to supplement the Idaho Power Company's effort. This should be accompanied by a regular water quality component. An updated monitoring criteria to assess the species' recovery should be developed and included in an updated recovery plan. Toxicology We have only limited data on water quality constituents that adversely affect the Bliss Rapids snail. Additional research is needed to assess how emerging contaminants (Atrazine, Neonicotinoids, pyrethroids) and nutrients (e.g., nitrates) can affect the species. An updated water quality criteria, that includes emerging contaminants such as these, should be developed and included in an updated recovery plan (USFWS, 2018).

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SPECIES ACCOUNT: *Triodopsis platysayoides* (Flat-spired three-toothed Snail)

Species Taxonomic and Listing Information

Listing Status: Threatened; 08/02/78; Northeast Region (R5) (USFWS, 2015)

Physical Description

Snail. Shell is heliciform and flattened. It is brown, finely and obliquely striate, has five whorls, and has a whitish, reflected lip at the aperture. A single short tooth is present on the parietal wall. Color is pale gray (Hotopp, 2000). (NatureServe, 2015)

Taxonomy

T. platysayoides is a formally recognized species. It was first collected by Graham Netting at Coopers Rock and later described by Stanley Brooks (1933) as Polygra platysayoides from the area of Coopers Rock State Forest (USFWS 1983, Watters 2006). Although the taxomic status of the species was questioned, in 1940 Pilsbry considered it to be a distinct species and transferred it to genusTridopsis (Stihler 1994). Based on rather limited information, Vagvolgyi (1968) classified T. platysayoides as a subspecies of T. complanata. This reclassification was not widely accepted and in 1974 Solem concluded that available evidence supports full species status (USFWS 1985) (USFWS, 2007).

Current Range

What was once considered a very narrow endemic species; found only in small area near the Cheat River at 3 separate locations; most accessible is summit of Cooper`s Rock State Park; is now still within a narrow range but is known from nearly 100 occurrences distributed on both sides of Cheat Gorge within an approximately 14-mile stretch including portions of major tributary ravines. Range begins near the mouth of Muddy Run near Ruthbelle in Preston Co., and extends to the lower reaches of the Cheat River near Tyrone in Monongalia; although it is still considered a narrow range endemic (USFWS, 2007).

Critical Habitat Designated

No;

Life History

Feeding Narrative

<u>Adult:</u> Crevices of exposed sandstone and talus of rock and caves; also feed in deep litter at base of major rocks. Close association with massive sandstone outcrops and talus; also at cave mouths and on limestone. Plants frequently found associated include sweet birch (Betula lenta), eastern hemlock (Tsuga canadensis), yellow birch (Betula allegheniensis) and great Laurel (Rhododendron maximum) (Hotopp, 2005). The species has coevolved with a rare mammal, the Alleghany wood-rat, Neotoma magister, and where the wood rat and snail coexist, wood-rats furnish a nearly constant food supply for the snail, including wood-rat excrement and a host of wood-rat harvested provisions carried into the snail's location (Dourson, 2008) (NatureServe, 2015). The species has coevolved with a rare mammal, the Alleghany wood-rat, Neotoma magister, and where the wood rat and snail coexist, wood-rats furnish a nearly constant food

supply for the snail, including wood-rat excrement and a host of wood-rat harvested provisions carried into the snail's location. Diet includes fungi, lichens, flower blossoms of the tulip tree Liriodendron tulipifera, deceased gray cave crickets Euhadenoecus fragilis, gray cave creicket excrement, yellow birch Betula allegheniensis, and sweet birch Betula lenta leaves. It also feeds on vacant shells of Xolotrema denotatum, Mesomphix cupreus, and its own kind (Dourson, 2008).; Peak activity for the species occurs after nighfall whereas peak feeding occurs when temperatures are between 18 and 23C and relative humidity between 70% and 85% (Dourson, 2008).; (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatreServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Species inhabits crevices of exposed sandstone and talus of rock and caves; also feed in deep litter at base of major rocks. Close association with massive sandstone outcrops and talus; also at cave mouths and on limestone. Plants frequently found associated include sweet birch (Betula lenta), eastern hemlock (Tsuga canadensis), yellow birch (Betula allegheniensis) and great Laurel (Rhododendron maximum) (Hotopp, 2005). The species has coevolved with a rare mammal, the Alleghany wood-rat, Neotoma magister, and where the wood rat and snail coexist, wood-rats furnish a nearly constant food supply for the snail, including wood-rat excrement and a host of wood-rat harvested provisions carried into the snail's location (Dourson, 2008) (NatureServe, 2015). High ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the specific habitat needs of this species and the limited number of known locations.

Dispersal/Migration

Motility/Mobility

Adult: Nonmigrant (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Terrestrial gastropods do not move much usually only to find food or reproduce. Olfaction is the primary sensory behavior utilized to find and move toward a food item (on the scale of cm to m) although Atkinson (2003) found that Anguispira alternata was capable of switching foraging behavior when snails encountered a physical barrier to movement. Fisher et al (1980) reported maximum movement rate of Rumina decollata (Linnaeus, 1758), an introduced pest species in California spreading relatively rapidly (for a snail), to be 20 m in three months (= 6.67 m/month) in an irrigated orchard. Tupen and Roth (2001) reported the movement rate for the same species in an un-irrigated native scrub on San Nicolas Island to be 0.4 km in 12 years (= 33.33 m/month). South (1965) found in dispersal studies of the slug, Deroceras reticulatum, that slugs traveled a mean distance of 1.13 m in seven days indicating this species disperses little throughout its life. Giokas and Mylonas (2004) found mean dispersal and minimal movement distances were very small (16.2 and 5.4 m, respectively) for Albinaria coerulea, with few individuals dispersing longer distances. Even the most extreme dispersal distances, such as 500 m for the giant African land snail Achatina fulica (Tomiyama and Nakane, 1993), do not approach the scale of km. Viable land snail populations generally occupy small areas. Frest and Johannes (1995) report the largest Oreohelix colony they observed was one mile (1.67 km) long and 0.25 miles (0.41 km) wide while the smallest was six feet (183 cm) long and two feet (61 cm) wide. As a whole, pulmonates (previously Subclass Pulmonata) are better dispersers than prosobranchs (previously Subclass Prosobranchia) possibly due to their hermaphroditic reproduction increasing the chance of new colonization (Pilsbry, 1948). When compared with prosobranch families, pulmonates generally reproduce at smaller sizes and sooner, produce greater numbers of eggs/young, have larger clutch sizes, greater growth rates, and shorter life cycles (Brown, 1991). Further, prosobranchs' requirement of constant moisture for oxygen exchange limits their ability to colonize drier habitats. Suitable habitat for pulmonate groups tends to be more varied and less restrictive than for prosobranch groups. All of these factors contribute to pulmonates greater dispersal capability over prosobranchs, as evidenced by the wider and more varied distribution of pulmonates over prosobranchs. Despite this, separation distance for both groups is set at the minimum one km as most movements are well within this suggested minimum separation distance (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decrease of <30% to increase of 25% (Population dependent) (NatureServe, 2015)

Resiliency:

Moderate (inferred from NatureServe, 2015)

Representation:

Moderate (inferred from NatureServe, 2015)

Redundancy:

Moderate (inferred from NatureServe, 2015)

Number of Populations:

21 - 300 (NatureServe, 2015)

Population Size:

1000 - 10,000 individuals (NatureServe, 2015)

Population Narrative:

Cooper`s Rock pop. has very restrictive range, but seems to be protected by secretive habits during drier weather. Genetic samples have been taking but poor funding has precluded analysis of these samples (USFWS, 2007); otherwise genetic information is lacking. Decline of <30% to increase of 25% Prior to Hotopp (2000), population est. at 300-500 individuals based on Grimm (1972), Solem (1974) and USFWS (1983); abundance data from Cooper`s Rock site only; total to date probably slightly less than 1000 individuals (Ken Hotopp, pers. comm., January 2005). The species appears to be very common where it is found, often the most abundant species present (USFWS, 2007). Pilsbry (1939) cites only on the summit of Cooper's Rock, Monongalia Co., West Virginia; but some 3 sites were reported (1983) by WV field office, 2 state- and 1 privately-owned (2 discovered very recently). Hubricht (1972) cites it only from below Coopers Rock, Monongalia Co., West Virginia. By the time the recovery plan (USFWS, 1983) was written, known range included 7 locations, all in close proximity to Cooper's Rock. Stihler (1994) discovered 11 new locations in Monogalia and Preston Cos., West Virginia (an area 2.1 by 8.7 miles). Hotopp (2000) documented the species occurrence in about 30 sites total (many newly discovered) in the Cheat River Canyon, West Virginia, increasing the previous number of known sites by threefold. Increasing survey work through 2006 has resulted in many new localities; such that the present known range includes 99 occurrences, including one at Cornwall Cave (approximately 6 miles south of Cooper's Rock) (USFWS, 2007). (NatureServe, 2015). Moderate resiliency, representation and redundancey are inferred based on the number of known populations and the apparent health of some of the populations.

Threats and Stressors

Stressor: Road building and logging (USFWS, 2007)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Road building and logging continue to be a threat to this species (USFWS, 2007).

Stressor: Fires (USFWS, 2007)
Exposure:
Response:
Consequence: Loss of individuals/Loss of food source
Narrative: Fire could killindividual snails and reduce leaf litter (USFWS, 2007).

Stressor: Residential development (USFWS, 2007)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Residential development is listed as a threat to this species (USFWS, 2007).

Stressor: Invasive plants (USFWS, 2007)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Invasive plants are listed as a threat to this species (USFWS, 2007)

Stressor: Predation (USFWS, 2007)
Exposure:
Response:

Consequence: Loss of individuals
Narrative: Predation by a wide variety of animals is listed as a threat to this species (USFWS, 2007).

Stressor: Inadequacy of existing regulatory mechanism (USFWS, 2007)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Regulatory mechanisims are lsrgely ineffective at protecting this species (USFWS, 2007).

Stressor: Declines in Allegheny woodrat population (USFWS, 2007)
Exposure:
Response:
Consequence: Loss of food source
Narrative: Declines in Allegheny woodrat population uis listed as a threat to this species food supply (USFWS, 2007).

Recovery

Delisting Criteria:
Recovery Option A: T. Platysayoides is found at less than three additional sites. 1. All known habitat sites supporting T. platysayoides are protected from foreseeable human impacts by acquisition, easements or cooperative agreements and management plans. This requires the protection of atleast 80 percent of the snail's habitat at each of the sites from impacts of recreational usage, adverse management practices, land use changes, or other actions that would adversely affect the species. 2. A long-term management and monitoring program is established for the species. 3. The monitoring program shows that there is no downward trend in distribution and number and extent of populations, or habitat quality for a 10-year period.
Recovery Option B: 1. T. platysayoides is found at a minimum of three additional sites (i.e. in addition to the known sites in Cooper's Rock State Park and at Table Rock), each at least a mile from the other and from the known sites. 2. At least 60 percent of these sites are protected from foreseeable human impacts by acquisition, easement or cooperative agreements and management plans. 3. A long-term management and monitoring program is established for the species. 4. The monitoring program shows that there is no downward trend in distribution, number and extent of populations, or habitat quality for a 10-year period (USFWS, 2007).

Recovery Actions:
- Option B applies because there are now 99 known sites for the species. Criterion 1 appears to be satisfied. The 99 known sites are spread out across a 14-mile stretch of the gorge. Progress towards criterion 2 has been made, but the criterion is not satisfied. Roughly 2/3 of the 99 known sites are on public land. These sites, however, face continuing threats from recreation. Progress towards criterion 3 has been made, but the criterion is not satisfied. A long-term management and monitoring plan has not been established for the species. Criterion 4 has not been met. While the known distribution of the species has increases, trend data and extent of populations are largely unavailable (USFWS, 2007).

Conservation Measures and Best Management Practices:

- Revision of the recovery plan to account for populations, connectivity, genetic exchange, and new threats discovered since the plan was written, and to provide objective, measurable recovery criteria that address the relevant listing factors (USFWS, 2007).
- Establishment of a long-term monitoring program, especially to discern the effectiveness of buffers for timber management practices (USFWS, 2007).
- Completion of long-term management agreements with land managers (USFWS, 2007).

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SPECIES ACCOUNT: *Tryonia alamosae* (Alamosa springsnail)

Species Taxonomic and Listing Information

Listing Status: Endangered; 09/30/1991; Southwest Region (R2) (USFWS, 2016)

Physical Description

Distinguishing features of the Alamosa springsnail include a conical shell that is up to 3 mm (0.1 inch) long, with well-impressed sutures separating regularly convex whorls. The male penis is a flattened blade with a conical glandular papilla on the left side towards the tip (Taylor 1983). Body color varies from opaque black to gray. The species exhibits distinct sexual dimorphism with females having a longer shell (1.41 mm for males and 2.30 for females) (Taylor 1987). Male shells have 3¼—4 whorls and the female 4—5½ whorls. In living animals, the thin shell is translucent (USFWS, 1994).

Taxonomy

The Alamosa springsnail (Tryonia alamosae) was first discovered by Taylor in 1979, and placed in the genus Tryonia. The species was described as Tryonia alamosae in 1987 (Taylor 1987) (USFWS, 1993).

Historical Range

See current range.

Current Range

The Alamosa springsnail is endemic to central New Mexico. The species is known only from a thermal spring complex in Socorro County, New Mexico. The spring complex consists of five individual springheads that flow together. The species also occurs in minor rivulets out of the main channel in the canyon where the springs arise (Taylor 1987) (USFWS, 1994).

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

<u>Adult: </u>Herbivorous, and feeds on algae and other materials that occur in the organic film on plants and debris (USFWS, 1993). On cobble, gravel and sand substrate with algal film in thermal (27-28 degrees C) spring pools and runs. More common in moderate than fast flowing water; often under algae or water cress mats. The site consists of five distinct sprinheads receiving water from the same source (USFWS, 1993). The snails are found mainly in situations where minor rivulets flow out of the main channel downstream of the sprinhead (Taylor, 1987). Pool; SPRING/SPRING BROOKBenthic (NatureServe, 2015)

Reproduction Narrative

<u>Adult: </u>The Alamosa springsnail is ovoviviparous, and contains a series of embryos in various stages of development. Because the Alamosa springsnail lives in a thermally constant environment, reproduction is probably not seasonal, and population size likely remains relatively stable (NMDGF 1985) (USFWS, 1993).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (Natureserve, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Species occurs on cobble, gravel and sand substrate with algal film in thermal (27-28 degrees C) spring pools and runs. More common in moderate than fast flowing water; often under algae or water cress mats. The site consists of five distinct springheads receiving water from the same source (USFWS, 1993). The snails are found mainly in situations where minor rivulets flow out of the main channel downstream of the springhead (Taylor, 1987). Benthic (NatureServe, 2015). High ecological integrity of the community and site fidelity as well as low tolerance ranges are based on this species unique habitat requirements and low number of known populations.

Dispersal/Migration

Motility/Mobility

Adult: Low (inferred from USFWS, 1993)

Dispersal

Adult: Low (inferred from USFWS, 1993)

Immigration/Emigration

Adult: Low (inferred from USFWS, 1993)

Dispersal/Migration Narrative

Adult: Low mobility, immigration/emigration and dispersal are inferred based on the snails thermal spring habitat and the lack of immigration corridors.

Population Information and Trends

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1000 - 2500 individuals (NatureServe, 2015)

Adaptability:

The limited range makes it vulnerable to habitat loss and alteration (USFWS, 1993). (NatureServe, 2015)

Population Narrative:

The limited range makes it vulnerable to habitat loss and alteration (USFWS, 1993). >10,000 individuals, but in < 1.5 km of small streams, based on density measures made by Mehlhop (1993). Two spring heads (Burton, 1994 indicates 3) and spring runs merge into a single run and form a single occurrence first discovered in 1979 (USFWS, 1993). A third springhead in soft mud to the south connects to the spring run, but does not support the species. A separate and the largest springhead and run supporting the species is approximately 0.8 km (0.5 mi) east. The spring runs flow into cool waters of Alamosa Creek where the snails do not occur (NatureServe, 2015).

Threats and Stressors

Stressor: Ground water depletion (USFWS, 1993)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Potential threats to the species include all activities that would significantly reduce spring flow or the food source that supports both springsnail species. Alterations to the watersheds, springs, or associated runs could cause a reduction in water flow, change in water temperature or water quality, modify habitat or food source, thus have a devastating impact on existing populations (USFWS, 1993).

Stressor: Limited range (USFWS, 1993)
Exposure:
Response:
Consequence: Extinction
Narrative: Some degree of security may be provided the Alamosa springsnail because the two spring systems where it occurs are physically separated. However, if the two systems rely on the same water source, a single disaster could eliminate both populations (USFWS, 1993).

Stressor: Non-native species (USFWS, 1993)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Potential introduction of exotic and non—native fishes or other aquatic organisms pose an additional threat due to potential predation or competition these organisms could exert upon springsnails (USFWS, 1993).

Stressor: Livestock grazing (USFWS, 1993)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Present land use surrounding the Alamosa springsnail spring complex includes livestock grazing. The current level does not appear to be harmful to Alamosa springsnail habitat (USFWS, 1993).

Stressor: Over-collection (USFWS, 1993)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Because of their rarity, both springsnails are of interest to biologists and collectors. Therefore, collection of animals is a minor but continuing threat. Collecting springsnail specimens for scientific purposes is regulated by the NMDGF. The level of collecting does not appear to adversely impact the springsnails' populations. Collection for scientific purposes should, however, continue to be closely monitored and regulated as appropriate to protect the wild population (USFWS, 1993).

Recovery

Reclassification Criteria:
Ensure extant populations and existing habitats are secured from threats (USFWS, 1993).

Delisting Criteria:
At least one additional population in other spring systems is established for each species. Each additional population must be maintained for a minimum of 5 consecutive years before it will be considered successful (USFWS, 1993).

Recovery Actions:
- 1. Work with landowners to develop a Habitat Management Plan for protection of springsnails' habitats. 2. Monitor and evaluate the existing populations and their habitat twice annually. 3. Determine life history and ecological needs. 4. Locate site and establish second populations of each species in presumed historic habitat, but disjunct from existing populations (USFWS, 1993).
- Updated recovery priority number 17 (USFWS, 2018).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS • Revise and Update the recovery plan. The current recovery plan is associated with the Alamosa springsnail as well as the Socorro springsnail. Work with state wildlife biologists and other experts to determine if this multi-springsnail recovery plan is the best approach for management of these species. Additionally there is no habitat management plan in place (one of the downlisting criteria) and establishment of additional Alamosa springsnail populations within the historic range (one of the delisting criteria) may not be a viable option. Because of these reasons, it is recommended that revised recovery plan(s) be completed. • Upon revision and updating of the recovery plan, incorporate recovery goals to address climate change (e.g. drought, monsoonal events, spring contamination). • Continue efforts to work on habitat

management plan or other forms of conservation agreements with the landowners. • Work with landowners and state wildlife biologists to continue to implement frequent monitoring of the springs and springsnails. • Work with state wildlife biologists and other experts to determine if is feasible to establish a population outside of Alamosa springsnails' historic range. • Work with state wildlife biologists and other experts to determine if captive refugium population is needed (USFWS, 2018).

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SPECIES ACCOUNT: *Tryonia cheatumi* (Phantom Tryonia)

Species Taxonomic and Listing Information

Listing Status: Endangered; 07/09/2013; Southwest Region (R2) (USFWS, 2016)

Physical Description

Shell medium-sized, conical. Penial ornament of 2 distal papillae along inner edge (Hershler, 2001). (NatureServe, 2015)

Taxonomy

The Phantom tryonia was first described by Pilsbry (1935, p. 91) as Potamopyrgus cheatumi. The species was later included in the genus Lyrodes and eventually placed in the genus Tryonia (Taylor 1987, pp. 38–39) (USFWS, 2013).

Historical Range

See current range. The historic range for the Phantom tryonia was likely not larger than present, but the species may have occurred in other springs within the San Solomon Spring system, such as Saragosa and Toyah Springs. It likely also had a wider distribution within Phantom Lake Spring and San Solomon Spring before the habitat there was modified and reduced (USFWS, 2013).

Current Range

Occurs only in the four remaining desert spring outflow channels associated with the San Solomon Spring system (San Solomon, Phantom, Giffin, and East Sandia springs) (USFWS, 2013).

Critical Habitat Designated

Yes; 7/9/2013.

Legal Description

On July 9, 2013, the U.S. Fish and Wildlife Service designated critical habitat for Phantom tryonia (Tryonia cheatumi) under the Endangered Species Act of 1973, as amended (78 FR 40970 - 40996). The critical habitat designation includes 4 critical habitat units, which encompass 3.7 acres (9.2 hectares) in Reeves and Jeff Davis counties, Texas. All units were occupied at the time of designation (USFWS, 2013).

Critical Habitat Designation

Four areas are designated as critical habitat for the Phantom Tryonia: (1) San Solomon Spring; (2) Giffin Spring; (3) East Sandia Spring; (4) Phantom Lake Spring.

San Solomon Spring Unit. The San Solomon Spring Unit consists of 1.8 ha (4.4 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. It is located in Reeves County, near Balmorhea, Texas. San Solomon Spring provides the water for the large swimming pool at Balmorhea State Park, which is owned and managed by the Texas Parks and Wildlife Department. The designation includes all springs, seeps, and outflows of San Solomon Spring, including the part of the concrete-lined pool that has a natural substrate bottom and irrigation ditch, and two constructed cie´negas. While the ditches do not provide all of the physical or biological features (such as submerged vegetation), there are sufficient features (including natural substrates on the ditch bottoms) to provide for the life-history processes of the species. Habitat in this unit is threatened by future declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, and the introduction of other nonnative species. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Giffin Spring Unit. The Giffin Spring Unit consists of 0.7 ha (1.7 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. It is located on private property in Reeves County, near Balmorhea, Texas, and its waters are captured in irrigation earthen channels for agricultural use. The designation includes all springs, seeps, sinkholes, and outflows of Giffin Spring. The unit contains most all of the identified physical or biological features essential to the conservation of the species. Habitat in this unit is threatened by declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, the introduction of other nonnative species, and further modification of spring outflow channels. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

East Sandia Spring Unit. East Sandia Spring consists of 1.2 ha (3.0 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. This unit is included within a preserve owned and managed by The Nature Conservancy (Karges 2003, p. 145) in Reeves County just east of Balmorhea, Texas. The designation includes the springhead itself and surrounding seeps and outflows. The unit contains all of the identified physical or biological features essential to the conservation of the species. Habitat in this unit is threatened by declining spring flows due to drought or groundwater withdrawals, the introduction of nonnative species, and modification of spring outflow channels. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Phantom Lake Spring Unit. Phantom Lake Spring consists of a small pool about 0.02 ha (0.05 ac) in size that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains the features essential to the conservation of these species. Phantom Lake Spring is owned by the U.S. Bureau of Reclamation about 6 km (4 mi) west of Balmorhea State Park in Jeff Davis County, Texas. The designation includes only the springhead pool. The physical or biological features of the habitat at Phantom Lake Spring have been maintained since 2000 by a pumping system and subsequent reconstruction of the spring pool. Although artificially maintained, the site continues to provide sufficient physical or biological features to provide for all the life-history processes of the three invertebrate species. Habitat in this unit is threatened by future declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, and the introduction of other nonnative species. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Primary Constituent Elements/Physical or Biological Features

Critical habitat units are designated for Jeff Davis County and Reeves County. Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of Phantom springsnail and Phantom tryonia are springs and spring-fed aquatic systems that contain:

(i) Permanent, flowing, unpolluted water (free from contamination) emerging from the ground and flowing on the surface;

(ii) Water temperatures that vary between 11 and 27 °C (52 to 81 °F) with natural seasonal and diurnal variations slightly above and below that range;

(iii) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for breeding, egg laying, maturing, feeding, and escape from predators;

(iv) Abundant food, consisting of algae, bacteria, decaying organic material, and submergent vegetation that contributes the necessary nutrients, detritus, and bacteria on which these species forage; and

(v) Either an absence of nonnative predators and competitors or nonnative predators and competitors at low population levels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, well pads, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on August 8, 2013.

The features essential to the conservation of the Phantom tryonia may require special management considerations or protection to reduce threats, such as reducing or eliminating water in suitable or occupied habitat through drought or groundwater pumping; introducing pollutants to levels unsuitable for the species; and introducing nonnative species into the inhabited spring systems such that suitable habitat is reduced or eliminated. Management activities that could ameliorate these threats include management of groundwater levels to ensure the springs remain flowing (all spring sites), managing oil and gas activities to eliminate the threat of groundwater or surface water contamination (Diamond Y Spring), maintaining the pump within Phantom Lake Spring to ensure consistent flow, managing existing nonnative species, red-rim melania, quilted melania, and feral hogs (San Solomon, Giffin, Phantom Lake, and Diamond Y Springs), and preventing the introduction of additional nonnative species (all spring sites).

Life History

Feeding Narrative

Adult: All of these snails are presumably fine-particle feeders on detritus (organic material from decomposing organisms) and periphyton (mixture of algae and other microbes attached to submerged surfaces) associated with the substrates (mud, rocks, and vegetation) (Allan 1995, p. 83; Hershler and Sada 2002, p. 256; Lysne et al. 2007, p. 649). Dundee and Dundee (1969, p. 207) found diatoms (a group of single-celled algae) to be the primary component in the digestive tract, indicating they are a primary food source (USFWS, 2013).

Reproduction Narrative

Adult: The lifespan of most aquatic snails is thought to be 9 to 15 months (Taylor 1985, p. 16; Pennak 1989, p. 552) (USFWS, 2013). These type of snails (snails in the former family Hydrobiidae) typically reproduce several times during the spring to fall breeding season (Brown 1991, p. 292) and are sexually dimorphic (males and females are shaped differently), with females being characteristically larger and longer-lived than males (USFWS, 2013).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: This species is currently only found in modified waters on the margins of spring flows. It is abundant on firm substrate and in soft mud downstream from the source before modification. Outflow from Phantom Lake Spring is led through a cement-lined irrigation canal with lateral ditches at intervals. From Phantom Lake spring to the first irrigation weir, about 300 feet, the canal is about 8 feet wide and has vertical cement walls and gravelly bottom with mud overlay as well as gates on either side of the weir with muddy embayments. This area is where Tryonia cheatumi are present. Associated species in Phantom Lake Spring are Cochliopa texana, Tryonia brunei, Physella mexicana, and Melanoides tuberculatus. This species, before site modification, was likely found in large creeks, and in a wider range of habitats than its other associates (Taylor, 1987; USFWS, 2003) Subterranean obligate (NatureServe, 2015). High ecological integrity of the population and site fidelity as well as low tolerance ranges are inferred based on species extremely restricted range and habitat requirements.

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 2013)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2013)

Dispersal

Adult: Low (USFWS, 2013)

Immigration/Emigration

Adult: Unlikely (USFWS, 2013)

Dispersal/Migration Narrative

Adult: Because of their small size and dependence on water, significant dispersal (in other words, movement between spring systems) does not likely occur, although on rare occasions aquatic snails have been transported by becoming attached to the feathers and feet of migratory birds (Roscoe 1955, p. 66; Dundee et al. 1967, pp. 89–90). In general, the species have little capacity to move beyond their isolated aquatic environments (USFWS, 2013).

Population Information and Trends

Population Trends:

Unknown (NatureServe, 2015)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

2500 - 1,000,000 individuals (NatureServe, 2015)

Population Narrative:

These snails likely have life spans of 9-15 months and reproduce several times during the spring to fall breeding season (Taylor, 1987). This species is extremely restricted and somewhat declining in unusual human created habitat so virtually no opportunity for natural dispersal without human intervention is possible (USFWS, 2003). There is no available information that the species' early historic distribution was larger than the present distribution. However, other area springs may have contained the same species, but because these springs have been dry for many decades, there is no opportunity to determine the potential historic occurrence of the snail fauna (USFWS, 2003). Unknown A healthy population (formerly estimated in the thousands but currently still healthy with lower densities) exists in a small area of Phantom Lake Spring, Phantom Cave, Texas (Dundee and Dundee, 1969; Taylor, 1987; Landye in litt. cited in USFWS, 2003), despite massive habitat alteration in the area. Similar habitat alteration occurred in San Solomon Spring in Balmorea State Park, but no recent population estimates are available, but historic population estimates place this population in the thousands. A newly discovered population in East Sandia Spring in Balmorea State Park with healthy population numbers (perhaps thousands) (USFWS, 2003). This species occurs only in the drainage of Toyah Creek, Pecos River basin, Texas (Hershler, 2001) in three spring systems (Phantom Lake, San Solomon Spring, and East Sandia Spring). Included in Toyah Creek tributaries are East Sandia Springs just east of Balmorhea in Reeves County, a small area of Phantom Lake Spring, Phantom Cave (Dundee and Dundee, 1969; Taylor, 1987) and San Solomon Spring in Balmorea State Park, Texas. (Taylor, 1987). Today the snails are limited to low densities in the small pool at the mouth of Phantom Cave and can not be found in the irrigation canal downstream (USFWS, 2003). In the summer of 2000, East Sandia Spring was surveyed for aquatic macroinvertebrates for the first time. A healthy abundance and diversity of springsnails (including what appears to be Phantom springsnail) were present in the small stream that makes up the spring outflow. The entire habitat is less than 150 meters in length (USFWS, 2003). (NatureServe, 2015). Low resiliency, representation and redundancy are based on the low number of known populations and the extremely restricted range this species inhabits.

Threats and Stressors

Stressor: Groundwater level decline (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The primary threat to the continued existence of the San Solomon Spring species is the degradation and potential future loss of aquatic habitat (flowing water from the spring outlets) due to the decline of groundwater levels in the aquifers that support spring surface flows. Habitat for these species is exclusively aquatic and completely dependent on spring flows emerging to the surface from underground aquifer sources. Spring flows throughout the San Solomon Spring system have and continue to decline in flow rate, and as spring flow declines, available aquatic habitat is reduced and altered. If one spring ceases to flow continually, all habitats for the Phantom springsnail, Phantom tryonia, and diminutive amphipod are lost, and the populations will be extirpated. If all of the springs lose consistent surface flows, all natural habitats for these aquatic invertebrates will be gone, and the species will become extinct.

Recovery

Recovery Actions:

- No recovery plan has been written for this species.

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/ecp0/. Accessed July 2016

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants

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Final Rule. 78 Federal Register 133, July 9, 2013. Pages 41228-41258

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

Determination of Endangered Species Status for Six West Texas Aquatic Invertebrates.

SPECIES ACCOUNT: *Tryonia circumstriata (=stocktonensis)* (Gonzales tryonia)

Species Taxonomic and Listing Information

Listing Status: Endangered; 07/09/2013; Southwest Region (R2) (USFWS, 2016)

Physical Description

A freshwater springsnail up to 5 mm in length. Shell medium- to large-sized, conical. Penial ornament of 2 distal papillae along inner edge and single, large, basal papillae on inner and outer edges (Hershler, 2001). (NatureServe, 2015)

Taxonomy

The Gonzales tryonia was first described as a late Pleistocene fossil record, Calipyrgula circumstriata, from the Pecos River near Independence Creek in Terrell County, Texas (Leonard and Ho 1960, p. 126). The snail from Diamond Y Spring area was first described as Tryonia stocktonensis by Taylor (1987, p. 37) (USFWS, 2013).

Historical Range

See currernt range. the historic distribution of the Gonzales tryonia may have been larger than the present distribution (USFWS, 2013).

Current Range

This species occurs only in the Diamond Y Spring system and associated outflows in Pecos County, Texas (Taylor, 1987; Hershler, 2001; USFWS, 2003). Late Pleistocene deposits along the Pecos River, above the mouth of Independence Creek, in Terrell Co., Texas, also contain shell material (Hershler, 2001; Leonard and Ho, 1960).

Critical Habitat Designated

Yes; 7/9/2013.

Legal Description

On July 9, 2013, the U.S. Fish and Wildlife Service designated critical habitat for Gonzales tryonia (Tryonia circumstriata) under the Endangered Species Act of 1973, as amended (78 FR 40970 - 40996). The critical habitat designation includes 1 critical habitat unit, which encompasses 178.6 acres (441.4 hectares) in Pecos County, Texas. This unit was occupied at the time of designation (USFWS, 2013).

Critical Habitat Designation

Four areas are designated as critical habitat for the Gonzales tryonia: (1) San Solomon Spring; (2) Giffin Spring; (3) East Sandia Spring; (4) Phantom Lake Spring.

San Solomon Spring Unit. The San Solomon Spring Unit consists of 1.8 ha (4.4 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. It is located in Reeves County, near Balmorhea, Texas. San Solomon Spring provides the water for the large swimming pool at Balmorhea State Park, which is owned and managed by the Texas Parks and Wildlife Department.

The designation includes all springs, seeps, and outflows of San Solomon Spring, including the part of the concrete-lined pool that has a natural substrate bottom and irrigation ditch, and two constructed cie´negas. While the ditches do not provide all of the physical or biological features (such as submerged vegetation), there are sufficient features (including natural substrates on the ditch bottoms) to provide for the life-history processes of the species. Habitat in this unit is threatened by future declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, and the introduction of other nonnative species. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Giffin Spring Unit. The Giffin Spring Unit consists of 0.7 ha (1.7 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. It is located on private property in Reeves County, near Balmorhea, Texas, and its waters are captured in irrigation earthen channels for agricultural use. The designation includes all springs, seeps, sinkholes, and outflows of Giffin Spring. The unit contains most all of the identified physical or biological features essential to the conservation of the species. Habitat in this unit is threatened by declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, the introduction of other nonnative species, and further modification of spring outflow channels. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

East Sandia Spring Unit East Sandia Spring consists of 1.2 ha (3.0 ac) that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains all of the features essential to the conservation of these species. This unit is included within a preserve owned and managed by The Nature Conservancy (Karges 2003, p. 145) in Reeves County just east of Balmorhea, Texas. The designation includes the springhead itself and surrounding seeps and outflows. The unit contains all of the identified physical or biological features essential to the conservation of the species. Habitat in this unit is threatened by declining spring flows due to drought or groundwater withdrawals, the introduction of nonnative species, and modification of spring outflow channels. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Phantom Lake Spring Unit. Phantom Lake Spring consists of a small pool about 0.02 ha (0.05 ac) in size that is currently occupied by the Phantom springsnail, Phantom tryonia, and diminutive amphipod and contains the features essential to the conservation of these species. Phantom Lake Spring is owned by the U.S. Bureau of Reclamation about 6 km (4 mi) west of Balmorhea State Park in Jeff Davis County, Texas. The designation includes only the springhead pool. The physical or biological features of the habitat at Phantom Lake Spring have been maintained since 2000 by a pumping system and subsequent reconstruction of the spring pool. Although artificially maintained, the site continues to provide sufficient physical or biological features to provide for all the life-history processes of the three invertebrate species. Habitat in this unit is threatened by future declining spring flows due to drought or groundwater withdrawals, the presence of nonnative snails, and the introduction of other nonnative species. Therefore, the physical or biological features in this unit may require special management considerations or protection to minimize impacts resulting from these threats.

Primary Constituent Elements/Physical or Biological Features

A critical habitat unit is designated for Pecos County, Texas. Within this area, the primary constituent elements of the physical or biological features essential to the conservation of Diamond tryonia and Gonzales tryonia are springs and spring-fed aquatic systems that contain:

(i) Permanent, flowing, unpolluted water (free from contamination) emerging from the ground and flowing on the surface;

(ii) Water temperatures that vary between 11 and 27 °C (52 to 81 °F) with natural seasonal and diurnal variations slightly above and below that range;

(iii) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for breeding, egg laying, maturing, feeding, and escape from predators;

(iv) Abundant food, consisting of algae, bacteria, decaying organic material, and submergent vegetation that contributes the necessary nutrients, detritus, and bacteria on which these species forage; and

(v) Either an absence of nonnative predators and competitors or nonnative predators and competitors at low population levels.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, roads, oil and gas well pads, and other paved areas) and the land on which they are located existing within the legal boundaries on August 8, 2013.

The features essential to the conservation of the Gonzales tryonia may require special management considerations or protection to reduce threats, such as reducing or eliminating water in suitable or occupied habitat through drought or groundwater pumping; introducing pollutants to levels unsuitable for the species; and introducing nonnative species into the inhabited spring systems such that suitable habitat is reduced or eliminated. Management activities that could ameliorate these threats include management of groundwater levels to ensure the springs remain flowing (all spring sites), managing oil and gas activities to eliminate the threat of groundwater or surface water contamination (Diamond Y Spring), maintaining the pump within Phantom Lake Spring to ensure consistent flow, managing existing nonnative species, red-rim melania, quilted melania, and feral hogs (San Solomon, Giffin, Phantom Lake, and Diamond Y Springs), and preventing the introduction of additional nonnative species (all spring sites).

Life History

Feeding Narrative

Adult: All of these snails are presumably fine-particle feeders on detritus (organic material from decomposing organisms) and periphyton (mixture of algae and other microbes attached to submerged surfaces) associated with the substrates (mud, rocks, and vegetation) (Allan 1995, p. 83; Hershler and Sada 2002, p. 256; Lysne et al. 2007, p. 649). Dundee and Dundee (1969, p. 207) found diatoms (a group of single-celled algae) to be the primary component in the digestive tract, indicating they are a primary food source (USFWS, 2013).

Reproduction Narrative

Adult: The lifespan of most aquatic snails is thought to be 9 to 15 months (Taylor 1985, p. 16; Pennak 1989, p. 552) (USFWS, 2013). These type of snails (snails in the former family Hydrobiidae) typically reproduce several times during the spring to fall breeding season (Brown 1991, p. 292) and are sexually dimorphic (males and females are shaped differently), with females being characteristically larger and longer-lived than males (USFWS, 2013).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Habitat of the species is mud substrates on the margins of small springs, seeps, and marshes in flowing water associated with sedges and cattails (Taylor, 1987). Other habitat factors, however, are certainly limiting as this species has not expanded beyond the immediate vicinity of the Diamond Y Spring system (first in the lower watercourse, then extirpated there but found in the upper watercourse) in over 40 years since its original description (USFWS, 2003). The only other associated mollusk species is Physella mexicana (Taylor, 1987). Benthic (NatureServe, 2015). High ecological integrity of the population and site fidelity as well as low tolerance ranges are inferred based on species extremely restricted range and habitat requirements.

Dispersal/Migration

Motility/Mobility

Adult: Low (USFWS, 2013)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (USFWS, 2013)

Dispersal

Adult: Low (USFWS, 2013)

Immigration/Emigration

Adult: Unlikely (USFWS, 2013)

Dispersal/Migration Narrative

Adult: Because of their small size and dependence on water, significant dispersal (in other words, movement between spring systems) does not likely occur, although on rare occasions aquatic snails have been transported by becoming attached to the feathers and feet of migratory birds (Roscoe 1955, p. 66; Dundee et al. 1967, pp. 89–90). In general, the species have little capacity to move beyond their isolated aquatic environments (USFWS, 2013).

Population Information and Trends

Population Trends:

Unknown (NatureServe, 2015)

Resiliency:

Low (NatureServe, 2015)

Representation:

Low (NatureServe, 2015)

Redundancy:

Low (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

50 - 2500 individuals (NatureServe, 2015)

Population Narrative:

These snails likely have life spans of 9-15 months and reproduce several times during the spring to fall breeding season (Taylor, 1987). This species and has very limited dispersal capability, especially considering the species only exists in an outflow to a single spring (USFWS, 2003). There is no available information that the species' historic distribution was larger than the present distribution. However, other area springs may have contained the same species, but because these springs have been dry for more than four decades, there is no opportunity to determine the potential historic distribution. Unknown In fall, 1984, D.W. Taylor, found that Gonzales springsnail was limited to only the lower watercourse in the first 30 meters (98.4 feet) of outflow from Euphrasia Spring. These findings were confirmed by Fullington (1991). More recent surveys have found that the Gonzales springsnail is now found only in the outflow stream of the Diamond Y head pool in the upper watercourse. This distribution is supported by recent observations of Dr. Robert Hershler's (pers. comm. in Echelle 1999). The reason for the apparent reversal in distributional patterns of this species within the Diamond Y Spring system since the surveys in 1984 is unknown (USFWS, 2003). In fall, 1984, D.W. Taylor, found that Gonzales springsnail was limited to only the lower watercourse in the first 30 meters (98.4 feet) of outflow from Euphrasia Spring, Diamond Y Spring system, in Texas. These findings were confirmed by Fullington (1991). More recent surveys (Echelle, 2001) have found that the Gonzales springsnail is now found only in the outflow stream of the Diamond Y head pool in the upper watercourse (where it was originally absent) but no longer in the lower watercourse. This distribution is supported by recent observations of Dr. Robert Hershler's (pers. comm. in Echelle, 1999). The reason for the apparent reversal in distributional patterns of this species within the Diamond Y Spring system since the surveys in 1984 is unknown (USFWS, 2003). (NatureServe, 2015). Low resiliency, representation and redundancy are based on their being only one known population of this species (a 30 meter stretch of spring outflow).

Threats and Stressors

Stressor: Groundwater level decline (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The primary threat to the continued existence of the Diamond Y Spring species is the degradation and potential future loss of aquatic habitat (flowing water from the spring outlets) due to the decline of groundwater levels in the aquifers that support spring surface flows (USFWS, 2013).

Recovery

Recovery Actions:

- A recovery plan has yet to be written for this species.

References

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Final Rule. 78 Federal Register 133. Pages 41228-41258

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

Determination of Endangered Species Status for Six West Texas Aquatic Invertebrates.

SPECIES ACCOUNT: *Tulotoma magnifica* (Tulotoma snail)

Species Taxonomic and Listing Information

Listing Status: Threatened; 1/9/1991; Southeast Region (R4) (USFWS, 2015)

Physical Description

A large freshwater snail with a shell that has prominent, spirally arranged knobs. (NatureServe, 2015)

Taxonomy

Tulotoma magnifica was described from the Alabama River in 1834 as Paludina magnifica by T.A. Conrad. An additional three species in the genusPaludina were described from the Alabama-Coosa River system between 1834 and 1841. Haldeman erected Tulotoma as a subgenus of Paludina in 1840 based on shell and opercle characters of the Alabama-Coosa species. All four species of the Tulotoma were differentiated by only minor differences in shell size, shape and sculpture and the genus is now considered monotypic by most authors (Clench 1962, Burch 1982) (USFWS, 1991).

Historical Range

Historically ranged widely in the Coosa River and its tributaries from Big Canoe Creek south to Wetumpka, and two localities in the Alabama River system, one in the main river in the vicinity of Claiborne and one in Chilatchee Creek (Hershler et al., 1990). This snail has almost vanished entirely from the main channel of the Coosa and is extirpated from the Alabama River. (NatureServe, 2015)

Current Range

Currently known from five tributaries of the Coosa (DeVries, 1993). Efforts are being made to restore populations into suitable habitat upstream of the Choccolocco Creek occurrence (DeVries, 1993). Best population on the Coosa River (Christman et al., 1996). Updated information in Devries et al. (2003) have shown the species to occur in four of the five sites documented by Hershler et al. (1990) with expanded locations in three of the tributaries, but not in the Ohatchee/Tallasseehatchee Creek area. (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Reproduction Narrative

Larvae: Takes one year to reach sexual maturity, and may occasionally live more than two years. Larger females produce more and larger offspring than smaller females (Christman et al., 1996).; (NatureServe, 2015)

Juvenile: Takes one year to reach sexual maturity, and may occasionally live more than two years. Larger females produce more and larger offspring than smaller females (Christman et al., 1996).; (NatureServe, 2015)

Adult: Takes one year to reach sexual maturity, and may occasionally live more than two years. Larger females produce more and larger offspring than smaller females (Christman et al., 1996) (NatureServe, 2015). Tulotoma congregate in colonies under large rocks or boulders. Studies ofthe extant Coosa River population indicates a life span of 2 to 4 years, however,the size and bulk ofhistorically collected shells may indicate longer life spans in historic populations. Offspring are born alive. Although females give birth year round, reproduction is concentrated in the spring. Tulotomagrow rapidly and reach sexual maturity in about 1 year. Dispersal is concentrated during periods of high water (USFWS, 2000).

Spatial Arrangements of the Population

Adult: Clumped (inferred from Natureserve, 2015)

Environmental Specificity

Adult: Narrow/specialist (inferred from Natureserve, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from Natureserve, 2015)

Site Fidelity

Adult: High (inferred from Natureserve, 2015)

Habitat Narrative

Larvae: The habitat is riffles and shoals on the undersides of large rocks (Hershler et.al., 1990). DeVries (1993) found that habitat, specifically substrate, velocities, and depth, ranged significantly among sampling sites. He noted that the snail was always observed on rocks (never on the substrate), and appeared to require some degree of moving water. Occurs or historically occurred only in the fast-flowing Coosa and Alabama Rivers and a few of the larger tributaries of the Coosa. Optimum habitat characterized by substrate with roughness values greater than 2, boulder densities greater than 2/square meter, rocks of dissimilar sizes and current velocities sufficient to prevent silt accumulation (Christman et al., 1996). Habitat varied considerably among sample sites but at least the presence of rocks was necessary for survival (DeVries et al., 2003). Water current speed and the abundance of other snail species were not related to abundance.,BIG RIVER; CREEK; High gradient; Low gradient; MEDIUM RIVER; Moderate gradient; RiffleBenthic (NatureServe, 2015)

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Dispersal/Migration

Motility/Mobility

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: Low (inferred based on the taxa)

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: Non-migratory (inferred based on the taxa)

Dispersal

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Dispersal/Migration Narrative

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: Dispersal is concentrated during periods of high water (USFWS, 2000).

Additional Life History Information

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Population Information and Trends

Population Trends:

Increasing (USFWS, 2008)

Resiliency:

Low (inferred from NatureServe, 2015)

Representation:

Low (inferred from NatureServe, 2015)

Redundancy:

Low (inferred from NatureServe, 2015)

Population Size:

100,000 - 1,000,000 individuals (NatureServe, 2015)

Population Narrative:

All populations isolated from historic wide range and large amount of genetic variation between them; may require future taxonomic work (DeVries et al., 2003). 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). DeVries (1993) reports that the range of its main channel habitat has been reduced by 98% and its range within tributaries has been reduced by approx. 50%. Historically it occurred from the Coosa River in St. Clair Co., to the Alabama River in Monroe Co., Alabama (Mirarchi, 2004). Decline of >70% (NatureServe, 2015). USFWS (2008) notes that there have been two new sub-populations found and that this warrants the reclassification from endangered to threatened. Low resiliency, redundancy and representation are based on the small geographic area this species is known to inhabit and its localized populations.

Threats and Stressors

Stressor: Non-point source pollution (USFWS, 2008)
Exposure:
Response:
Consequence: Loss of habitat/ loss of individuals
Narrative: This species populations are extremely localized. Therefore, they are vulnerable to non-point source pollution (USFWS, 2008).

Stressor: Catastrophic events (USFWS, 2008)
Exposure:
Response:
Consequence: Loss of habitat/ loss of individuals
Narrative: Localized populations are extremely vulnerable to either natural or man made catastrophic events (USFWS, 2008).

Recovery

Reclassification Criteria:
Recommended to downlist to threatened (USFWS, 2008)

Recovery Actions:

- Although tulotoma are only known to inhabit 35 miles of stream and river channels, any individual event is unlikely to seriously impact all eight surviving populations simultaneously. The large numbers of snails, the number of surviving populations, the mature of their river and large stream habitats, and the improvement of their status makes it unlikely that tulotoma will become extinct within the foreseeable future. Therefore, the best scientific and commercial data available indicate that tulotoma is no longer an endangered species. Tulotoma remains extirpated from a significant portion of its historic range. Surviving drainage populations are isolated and remain vulnerable to changes in water quality, land use run-off, toxic spills, as well as floods and droughts. Therefore, threatened status is currently appropriate for this species (USFWS, 2008).

Conservation Measures and Best Management Practices:

- Develop and implement a monitoring plan for all populations (USFWS, 2008).
- Work with local communities to develop and implement watershed management plans protective of tulotoma populations and their aquatic habitats (USFWS, 2008).

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