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)

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). Currently, there are 305 A. lila individuals in captivity and 200 individuals released into an enclosure with ʻōhiʻa trees (Table 4). Presently, ROD has not altered the species composition or structure of the native rain/cloud forests on Oʻahu, but the confirmed presence of ROD on Oʻahu is a significant threat to the habitat of Achatinella spp. (USFWS, 2019a)

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:
1. At least 6 to 10 stable populations (possibly actively managed) are distributed across the known historical range of the species. Also, each ESU of the species (or each GU if ESUs have not been identified) must be represented by one or more stable populations; thus any species for which more than six GUs or ESUs are identified will require more than six stable populations to represent every GU or ESU. 2. To be considered stable, a population must number at least 300 individuals distributed across all size classes combined, and must have a population growth curve that is stable or positive for at least 4 of 5 sequential years. (USFWS, 2019b)

Delisting Criteria:
1. At least 12 to 20 populations are distributed across the known historical range of the species. Also, each ESU of the species (or each GU if ESUs have not been identified) must be represented by at least 2 populations; thus any species for which more than 6 GUs or ESUs are identified will require more than 12 populations to sufficiently represent every GU or ESU. 2. Each of these populations must have a population growth curve that is stable or positive for at least 7 of 10 sequential years, and have available habitat that is capable of supporting natural dispersal, expansion of the occupied range, and positive population growth. Any new populations that are established through natural dispersal from these populations should also maintain a positive growth trajectory for 4 of 5 sequential years. 3. At least 12 populations must number at least 300 individuals, distributed across allsize classes combined. (USFWS, 2019b)

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).
- 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).
- 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).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: The recovery strategy for the genus Achatinella centers on habitat protection and management, predator control, and studying the impacts from climate change on all the main Hawaiian islands. • Assessing the systematics of Achatinellidae and relationships within all Hawaiian subfamilies include the Achatinellinae. • Research on snail diseases as this can have a large impact in captive rearing (D. Sischo 2019, pers. comm.). • Rosy wolf snail o Survey and monitor distribution of rosy wolf snail. o Identify biology, life history, ecology of the rosy wolf snail. o Identify control and exclusion techniques. o Gene drive research • Jackson's chameleon o Identifying the fundamental-niche requirements to predict areas that are susceptible to colonization by natural migration or if limitations are overcome by human-facilitated releases (Soberón and Peterson 2005 in Kraus et al. 2012, p. 586). o Identifying intraspecific interactions as Jackson's chameleon niche expands (Van Kleek et al. 2018, p. 14). o Identify the geographic distribution and population density of Jackson's chameleons in the Waiʻanae and Koʻolau Mountain Ranges with particular interest in areas where there are wild populations of Achatinella or within habitats similar to where snails are known from (Kraus et al. 2012, p. 590; Chiaverano and Holland 2014, p. 121). o Quantify the predation pressure Jackson's chameleons exert (Kraus et al. 2012, p. 590) on Achatinella spp. • Diet o Research and manufacture an appropriate diet for captive rearing to expand breeding options (D. Sischo 2019, pers. comm.) o Study the effects of abrupt diet changes on the immediate health and long-term fitness (O'Rorke et al. 2016, p. 8) of all extant Achatinella spp. o Study the role of snails in structuring their microbial environment (O'Rorke et al. 2016, p. 8). o Study microbial habitats specific to Achatinella spp. where snails are still present in the wild. o Identify the need to incorporate microbial habitat manipulation into Achatinella spp. release plans. • Climate Change o Identify locations in both the Waiʻanae and Koʻolau Mountain Ranges that may sustain populations of Achatinella spp. within their historical ranges as weather patterns change. o Design and construct predator-proof enclosures to protect habitat and snails from habitat degradation and predation as the climate changes. (USFWS, 2019a)
- New management: Ongoing and planned management actions will benefit the genus Achatinella by mitigating predation. These include: Snail Extinction Prevention Program (SEPP) This program was created in 2012 by the Hawaiʻi Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) and PIFWO. The mission of SEPP is to: "Prevent the extinction of rare land snail species in all families and preserve the ecosystems in which these species and their local assemblages depend on throughout the Hawaiian Islands." This will be accomplished by following these objectives: • Preventing the imminent extinction and local extirpation of imperiled land snail species • Integrate ex situ captive rearing and in situ management • Sync rare snail conservation objectives and management techniques across entities and islands. In 2014, SEPP's strategic plan for 2015-2019 was a guide, not only for their actions but to communicate their ideas and timelines with other conservation partners, and to encourage discussion and combine funds and staffing to accomplish their mission. SEPP conducts surveys and monitors known snail populations, conducts predator control, assists in the design and upgrades of temporary and permanent predator-proof snail exclosures, and runs the captive propagation lab, which is a primary tool in preventing the extinction of many of the species listed in Table 4. In addition, SEPP provides technical assistance to managers of private lands and businesses and other State and Federal agencies. Snail Exclosures Predator-proof exclosures are currently the most effective conservation tool to protect snail populations in the wild. There are currently eight exclosures, six in the Waiʻiane and two (one under construction) in the Koʻolau Mountain Ranges. One exclosure in the Waiane Mountain Range has

been rebuilt, expanding the original footprint and incorporating the newer predator barriers that the old exclosure did not have. OANRP and SEPP have plans to construct additional exclosures in both the Waiʻiane and Koʻolau Mountain Ranges. The goal is to have at least one representative population of all extant Achatinella sp. protected inside an exclosure (DOFAW 2017, p. 25). (USFWS, 2019a)

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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). Coineau and Boutin (1992) demonstrated that interstitial habitats are critically important to the dispersal capabilities of animals with limited movements. Comacho (1992) suggested that the size, porosity, and compaction of sediment grains (e.g., clay vs. sand) was a limiting factor in the availability of interstitial habitats to aquatic cave organisms. (USFWS, 2003)

Population Information and Trends

Population Trends:

Declining (USFWS, 2003)

Species Trends:

Declining (USFWS, 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: Diminished 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)
- 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

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

Reclassification Criteria:
Maintain the presence of each species in the occupied management units as of the start of this plan, with a stable or increasing average trend in density over 10 years at currently monitored management units (1 and 3) (USFWS, 2019)

Develop, implement, and fulfill a water management plan or equivalent conservation agreement, 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, 2019)

3a: Long-term commitments (Conservation Agreements etc) are in place and will continue to maintain sufficient water quality protections for 10 years, and water quality sustains each species as measured by Criterion 1 above. (USFWS, 2019)

3b: Long-term commitments (Conservation Agreements etc) 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 for 10 years. (USFWS, 2019)

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, 2019)

Delisting Criteria:
Criterion 1: Maintain the presence of each species in the occupied management units as of the start of this plan, with a stable or increasing average trend in density over 10 years at currently monitored management units (1 and 3). (USFWS, 2019)

Criterion 2: Develop, implement, and fulfill a water management plan or equivalent conservation agreement, 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 20 years. (USFWS, 2019)

Criterion 3a: Long-term commitments (Conservation Agreements etc) are in place and will continue to maintain sufficient water quality protections for 20 years, and water quality sustains each species as measured by Criterion 1 above. (USFWS, 2019)

Criterion 3b: Long-term commitments (Conservation Agreements etc) 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 for 20 years. (USFWS, 2019)

g Criterion 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, 2019)

Recovery Actions:

- A Recovery Plan has not been developed for this species.
- 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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Listing Roswell springsnail, Koster's springsnail, Noel's amphipod, and Pecos assiminea as Endangered With Critical Habitat

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USFWS. 2019. Recovery Plan for Four Invertebrate Species of the Pecos River Valley: Noel’s amphipod (Gammarus desperatus), Koster’s springsnail (Juturnia kosteri), Roswell springsnail (Pyrgulopsis roswellensis), and Pecos assiminea (Assiminea pecos) Southwest Region, Albuquerque, New Mexico.

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)

Population Growth Rate:

Decline of 70-90% (NatureServe, 2015)

Number of Populations:

10 (USFWS, 2022)

Population Size:

<20,000 total (USFWS, 2022)

Population Narrative:

From 2006 through 2011, nine sub-populations of E. newcombi were documented in Hanakoa and Kalalau Valleys, including seven sites unknown when the USFWS Recovery Plan was published in 2006 (Wood 2017). The estimates of these populations were 7,620-10,690 snails in both valleys (Boynton & Wood 2007; Wood 2008; Wood 2011). In February 2015, an additional previously unknown colony of E. newcombi was documented at Hinalele Falls for the first time since 1925, with estimates of 8,000-10,000 individuals. This colony also represents the highest elevation that E. newcombi has ever been recorded (Wood 2017). In February 2015, 5,000-7,000 individuals were also observed on the northeastern slopes of Kalalau. In March 2019, a population of an estimated 10,000 individuals were observed at Upper Wailua/Blue Hole after hunters reported seeing native snails in the area (USFWS, 2022).

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)

Stressor: Red Cardinals (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Numerous red-crested cardinals (Paroaria coronata) were observed feeding on freshwater snails along the Hanakoa stream in 2015. Whereas 50 individuals of E. newcombi were originally observed at this location, none were found after observations of the cardinals predating snails were made (Wood 2017). The cardinals have been seen at multiple sites that E. newcombi are observed and could be a considerable threat depending on the site and status of the species (USFWS, 2022).

Stressor: Climate change (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Since the snails have such specialized habitat at the edge of streams, they are very susceptible to impacts from climate change (Hayes 2022). These impacts to the stream habitats where E. newcombi is found are due mainly through increases in the frequency and duration of drier periods. In addition, increasing flood events can wipe out native plant species along streams, which are then replaced with invasive species, a key threat to E. newcombi. Invasive plants are widespread at the sub-population locations of E. newcombi (USFWS, 2022)

Stressor: Non-Native species (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Non-native lymnaeids, flatworms and other parasites are an understudied threat to E. newcombi (Hayes 2022). • Goats (Capra hircus), rats (Rattus sp.), marsh flies, pigs (Sus scrofa), and the American bullfrog (Rana catesbiana) remain threats (USFWS, 2022)

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).
- 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).

Conservation Measures and Best Management Practices:

- New Management Actions: • Surveys, inventories, and monitoring – A Cooperative Agreement is in place between the U.S. Fish and Wildlife Service and Bishop Museum to review the conservation status and genetics of freshwater aquatic snails statewide in Hawaiʻi, including E. newcombi. Surveys are being completed in FY 2022 by staff at Bishop Museum. • Captive rearing to encourage reproduction – E. newcombi and Hawaiʻi's other freshwater snails are great candidates for captive rearing. Bishop Museum is working with the Department of Land and Natural Resources (DLNR) Snail Extinction Protection Program (SEPP) to collect and rear snails from Oʻahu in the same family as E. newcombi. Once these captive rearing methods are developed and successful, they can be expanded to E. newcombi (USFWS, 2022).
- Recommendations for Future Actions: No significant new information regarding the species biological status have come to light since the last 5-year review in 2017. Thus, the following recommendations for future actions are reiterated for 5-year review for 2022. • Population biology research – Conduct research and monitoring essential to the conservation of the species. • Predator / herbivore monitoring and control – Identify and manage predation. • Other threats monitoring and control – Identify and mange interspecific interaction • Spring and instream flow protection – Maintain stream and spring flows to protect Newcomb's snail habitat. • 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 Hanakāpiʻai 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. • The U.S. Fish and Wildlife Service Draft Recovery Plan for Erinna newcombi includes the primary goal of establishing baseline population numbers for the species. In addition, the plan calls for field research specifically within the historical ranges of Hanakoa, Wainiha, and Hanakāpiʻai to confirm if the snails are present. • Continue to survey for E. newcombi as well as the other freshwater snail species that are estimated to have even lower populations numbers than E. newcombi to help achieve listing status for those other species (USFWS, 2022).

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

Species Taxonomic and Listing Information

Listing Status: Endangered; 1/17/1995; California/Nevada (Region 8)

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).

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).
- 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:

Stable (USFWS, 2020)

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. Considering seasonal variation, the four invertebrate species exhibited an overall stable trend in each management unit from 2014 to 2017 (Johnson et al. 2019, page 154-159). Roswell and Koster's springsnails have been translocated to the Rio Hondo system, and have improved the redundancy of both springsnails by increasing their number of populations and spatial distribution on Bitter Lake NWR. (USFWS, 2020)

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, 2019).

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, 2019).

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, 2019).

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, 2019).

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, 2019).

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, 2019).

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, 2019).

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, 2019).

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, 2019).

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, 2019).

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).
- 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).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS (a) Continue investigations of survey and monitoring techniques for Pecos assiminea to better approximate density and distribution. (b) Further investigate to quantify the extent and implications gene flow between populations of Roswell and Koster's springsnail. (c) Understand the flow-ecology relationships between spring discharge and population dynamics to better understand snail movements and distribution, including seasonal variation. (d) Develop monitoring protocol for surveying for Gammarus lacustris or other amphipod species at Bitter Lake NWR. Create a field key for monitoring that will differentiate between Gammarus desperatus and other Gammarus species. (e) Identify potential translocation sites on and off Bitter Lake NWR. (f) Explore alternative conservation methods with landowners surrounding occupied habitat for the four listed invertebrates to protect water quantity/quality and improve habitat management. (g) Further investigate Noel's amphipod population genetics to determine the species status on the Bitter Lake NWR. (h) Monitor and assess the effects of fire on the Pecos assiminea to help determine the best methods of burning an occupied area while minimizing loss. (i) Reduce invasive plant species. (j) Continue monitoring springsnails and amphipods to determine abundance relationships among habitat characteristics, stream discharge, and groundwater levels. (USFWS, 2020)

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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)

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)

Amended Recovery Criteria. 1. The existing population in the Oostanaula River in Georgia maintains a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factors A and E). 2. A minimum of 5 new populations in the Coosa River drainage exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factors A, C and E). 3. A long-term agreement with hydropower operators is established that provides assurances that the flows in the Coosa and Oostanaula rivers will be operated such that water quality and flow regimes provide suitable habitat for the new populations within Federal Energy Regulatory Commission boundaries in the Coosa River drainage area (addresses Factor A). (USFWS, 2019)

Recovery Actions:
- 1. Remaining riverine habitat currently known for each species has been monitored and protected. Recovery Tasks 1.1, 1.2, 1.3, 1.41- 1.45, 2.1, 2.2, 3.1, and 3.2 will contribute to this criterion. 2. Although critical habitat was designated at the time of listing, there is still considerable information we do not know about the life history and specific habitat requirements for these species. Critical research and monitoring on life history and habitat requirements has been implemented. Recovery Tasks 1.1, 4.0, 5.1, 5.3, 5.4.1, and 5.42 will contribute to this criterion. 3. The range of each species includes three or more distinct drainages. This includes those locations where the species is known to occur. Recovery Tasks 7.1, 7.2, and 7.3 will contribute to this criterion (USFWS, 2014).
- There are no known threats to any of these species due to disease. There is no direct evidence at this time that predation is detrimentally affecting the Georgia pigtoe, interrupted rocksnail, or rough hornsnail. However, increasing their population sizes and ranges will reduce their vulnerability to threats of predation from natural or introduced predators. This is addressed under Factor A, above, and E, below (USFWS, 2014).
- Under the consultation requirements of the Endangered Species Act, existing regulatory mechanisms (e.g., the Clean Water Act and associated State Laws, Rivers and Harbors Act, etc.) afford consideration of the species when projects are reviewed. Information derived under Recovery Tasks 1.2, 1.3, 1.4.1-1.4.5, 2.1, and 2.2 will facilitate these consultations (USFWS, 2014).
- All threats affecting the Georgia pigtoe, interrupted rocksnail, or rough hornsnail, are influenced by their small population sizes and limited ranges. The following criteria shall serve to indicate a reduction in this threat: 1. Successful hatchery/captive propagation programs have been established for each species. Recovery Task 6.0 is essential to this criterion. 2. The range of each species has been extended to three or more distinct drainages. Recovery Tasks 7.1, 7.2, and 7.3 will contribute to this criterion. 3. Sustainable natural reproduction and recruitment has been demonstrated in each population. Recovery

tasks 1.1, 2.1, 2.2, 3.1, 3.2, and 7.3 address this criterion (USFWS, 2014).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Additional monitoring of known locations and habitat conditions. • Additional surveys for new populations and potential habitats for reintroduction should be evaluated. • Continue working with Alabama Power Company and partners to monitor and improve physical and chemical habitats in the Weiss Bypass, downstream of Jordan, and at other potential reintroduction sites. • Conduct research to document life history and habitat needs, including environmentally relevant toxicological information on similar species, as specific toxicity threats aren't well understood for the Pleuroceridae. • A review of the entire Pleuroceridae family should be conducted to better define current species boundaries and understand the evolution of life history strategies. • Pursue opportunities including land acquisition, conservation easements, and other conservation opportunities adjacent to large water habitats preferred by the species. • Perform large and sustained reintroduction efforts (approximately 10,000 individuals per year for a minimum of 3 years) to increase chances of establishing a recruiting population. • Create and implement an outreach program aimed at educating farmers, developers, and other landowners in the species' range about good land use practices and water conservation. • Develop a contingency plan for spill response(s) or natural disaster within occupied snail habitat. • Develop new and continue using existing partnerships like the Alabama Rivers and Streams Network to utilize conservation initiatives with landowners along the riparian habitats and within the upper Coosa River Basin. (USFWS, 2020)

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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). Lanai (USFWS, 2021)

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)

Number of Populations:

2 (USFWS, 2021)

Population Size:

<50 (USFWS, 2021)

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.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Finalize the recovery plan with measureable downlisting and delisting criteria for the recovery of Partulina semicarinata. • Conduct surveys for extant populations throughout the range of Partulina semicarinata. • Monitor and assess abundance of individuals and growth trend of populations. • Protect existing populations in the wild from threats. • Expand the capacity of the captive rearing program and increase the number of captive-reared individuals and populations. • Identify and prepare suitable habitats for translocation of captive-reared Lānaʻi tree snail. • Construct and maintain tree snail predator-proof enclosures to protect extant populations or to protect translocated Lānaʻi tree snails. • Increase numbers of populations and individuals in suitable habitat through translocation to build resilient populations with redundancy and representation. • Control invasive, nonnative plant species that degrade the wet forest habitat of Partulina semicarinata. • Implement effective control methods for nonnative Euglandina spp. at all Partulina semicarinata populations in habitats. • Expand and continue to implement effective control methods for rats in all Partulina semicarinata populations. • Implement effective control methods for Jackson's chameleon at all Partulina semicarinata populations. • Control any new threats to Partulina semicarinata before they become widespread. • Develop fine-scale climate models to identify future suitable habitat based on existing and historical distributions and determine potential future climate conditions. • Identify, develop, and support alliances and partnerships to plan and implement Partulina semicarinata habitat restoration, protection from predators, and management to benefit and recover the species. (USFWS, 2020)

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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). USFWS. 2021. Draft recovery plan for 44 species from the islands of Maui, Molokaʻi, Kahoʻolawe, and Lānaʻi (Maui Nui). Portland, Oregon. xvi + 77 pages.

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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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.

USFWS, 2020. Partulina semicarinata (Lānaʻi tree snail). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawaiʻi. 24 pp.

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). Lanai (USFWS, 2021)

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. 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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)

Number of Populations:

10 (USFWS, 2021)

Population Size:

>100 (USFWS, 2021)

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.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Finalize the recovery plan with measureable downlisting and delisting criteria for the recovery of Partulina variabilis. • Conduct surveys for extant populations throughout the range of Partulina variabilis. • Monitor and assess abundance of individuals and growth trend of populations. • Protect existing populations in the wild from threats. • Expand the capacity of the captive rearing program and increase the number of captive-reared individuals and populations. • Identify and prepare suitable habitats for translocation of captive-reared Lānaʻi tree snail. • Construct and maintain tree snail predator-proof enclosures to protect extant populations or to protect translocated Lānaʻi tree snails. • Increase numbers of populations and individuals in suitable habitat through translocation to build resilient populations with redundancy and representation. • Control invasive, nonnative plant species that degrade the wet forest habitat of Partulina variabilis. • Implement effective control methods for nonnative Euglandina spp. at all Partulina variabilis populations in habitats. • Expand and continue to implement effective control methods for rats in all Partulina variabilis populations. • Implement effective control methods for Jackson's chameleon at all Partulina variabilis populations. • Control any new threats to Partulina variabilis before they become widespread. • Develop fine-scale climate models to identify future suitable habitat based on existing and historical distributions and determine potential future climate conditions. • Identify, develop, and support alliances and partnerships to plan and implement Partulina variabilis habitat restoration, protection from predators, and management to benefit and recover the species. (USFWS, 2020)

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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)

Number of Populations:
3 (USFWS, 2022)

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). At the time of listing, the rough hornsnail was known from two locations, one in the Lower Yellowleaf Creek and another in the Lower Coosa River. The addition of the Mitchell Reservoir population and the expansion of the Yellowleaf Creek population, moves the rough hornsnail towards meeting its recovery criteria and bolsters its redundancy in the Coosa River watershed (USFWS, 2022).

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).

Recovery Priority Number: 11C

Delisting Criteria:
1. At least four (4) populations exhibit a stable or increasing trend, natural recruitment, and multiple age classes (addresses Factors A and E) (USFWS, 2022)

2. At least one (1) population (as defined in Criteria 1) must occur within the Lower Coosa River (HUC8: 03150107) and one (1) population (as defined in Criteria 1) must occur within the Middle Coosa River (HUC8: 03150106) (addresses Factors A and E) (USFWS, 2022).

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (addresses factors A, D, and E). a. A long-term agreement with hydropower operators is established that provides assurances dams will be operated such that water quality and flow regimes provide suitable habitat in areas influenced by dam operations (addresses factors A, D, and E) (USFWS, 2022).

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).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIVITIES • Conduct qualitative and quantitative surveys within known habitats and continue surveys in other areas (especially within the upper portions of the rough hornsnail's historic range) to find additional populations, including documentation of local threats • Acquire brood stock for captive propagation. • Conduct genetic and histology research to inform propagation and culture work and ensure fitness of reintroduced populations. • Investigate and identify potential sites for the future reintroduction of captively reared individuals. • Document specific life history and habitat needs; examine unknown components of life history and ecology, including physiochemical parameters of the stream habitats used by the rough hornsnail. • Work with local landowners to preserve the integrity of stream banks and riparian zones within known habitat and mitigate problem areas with appropriate conservation and restoration practices. • Restore rough hornsnail critical habitat through activities such as bank stabilization, riparian buffer maintenance/augmentation, adherence to best management practices, and other watershed-scale conservation efforts. • Develop contingency plans to respond to a spill or natural disaster, or other stochastic event within or upstream of occupied habitat. • Coordinate with the appropriate agencies to begin conducting water chemistry analyses to evaluate toxicity levels of CWA regulated chemicals on the rough hornsnail, as well as other native freshwater species (USFWS, 2022).

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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)

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.

Stressor: Declining water quantity and degraded water quality. (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: The major threats for this species are declining water quantity and degraded water quality. (USFWS, 2020)

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

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USFWS. 2020. Species status assessment for the Diamond Tryonia (Pseudotryonia adamantina), Gonzales Tryonia (Tryonia circumstriata), and Pecos Amphipod (Gammarus pecos). Version 1.0 November 20, 2020. Austin, TX. 106 pp.

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

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.

-

Additional Threshold Information:

-
-

References

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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

This 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

Number of Populations:

1 (USFWS, 2019)

Population Narrative:

The Chupadera springsnail is a rare, hydrobiid snail that survives in one thermal spring source located on private land in Socorro County, New Mexico. Critical habitat was also designated at the time of listing. Population numbers in Willow Spring appear to be similar to historic levels however, no springsnails have been detected at the unnamed spring in over two decades. (USFWS, 2019)

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.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Draft a recovery plan (or include this species in a multi-species springsnail recovery plan). Work with state wildlife biologists and other experts to determine recovery criteria and if including this springsnail in a multi-species recovery plan is the best approach for management of these species. • Address climate change in the recovery plan, incorporate recovery goals to address climate change. • Continue efforts to work on habitat management plan (including TESF work) or other forms of conservation agreements with the landowners. • Work with landowners, state wildlife biologists and others to continue to implement frequent monitoring of the springs and springsnails. • Work with landowners, state wildlife biologists and others on restoration efforts at the unnamed spring so that it could again support the species. • Work with state wildlife biologists and others to investigate the species' genetics. • Work with state wildlife biologists, TESF biologists and other experts to determine if captive refugium population is needed. (USFWS, 2019)

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Determination of Endangered Status for the Chupadera Springsnail and Designation of Critical Habitat. Final Rule. FR Vol. 77, No. 134. Pages 41088-41106.

USFWS. 2019. Chupadera springsnail (Pyrgulopsis chupaderae) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service New Mexico Ecological Services Field Office Albuquerque, New Mexico. 23 pp.

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)

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).
- 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).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS (a) Continue investigations of survey and monitoring techniques for Pecos assiminea to better approximate density and distribution. (b) Further investigate to quantify the extent and implications gene flow between populations of Roswell and Koster's springsnail. (c) Understand the flow-ecology relationships between spring discharge and population dynamics to better understand snail movements and distribution, including seasonal variation. (d) Develop monitoring protocol for surveying for Gammarus lacustris or other amphipod species at Bitter Lake NWR. Create a field key for monitoring that will differentiate between Gammarus desperatus and other Gammarus species. (e) Identify potential translocation sites on and off Bitter Lake NWR. (f) Explore alternative conservation methods with landowners surrounding occupied habitat for the four listed invertebrates to protect water quantity/quality and improve habitat management. (g) Further investigate Noel's amphipod population genetics to determine the species status on the Bitter Lake NWR. (h) Monitor and assess the effects of fire on the Pecos assiminea to help determine the best methods of burning an occupied area while minimizing loss. (i) Reduce invasive plant species. (j) Continue monitoring springsnails and amphipods to determine abundance relationships among habitat characteristics, stream discharge, and groundwater levels. (USFWS, 2020)

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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)

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:

4 (USFWS, 2023)

Population Size:

>1,000,000 individuals in all populations. Populations range from 100's to Millions (USFWS, 2023)

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. Four populations. East Sandia Spring 83,324 (10,983-155,664) West Sandia Spring: 478 (0-1,414) San Solomon Spring (canal, ciénegas, and pool combined): 3,942,386 (205,237-7,762,262) Phantom Lake Spring: 12,273,840 (4,841,039-19,706,641)

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.

Stressor: Climate Change (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: spur municipal and industry (i.e., agriculture and petroleum interests) demands for increased groundwater pumping, potentially affecting spring flows (Mace and Wade 2008, pp. 657-658; Taylor et al. 2012, p. 3). Prolonged drought has the potential to drive demand for additional groundwater resources that could impact regional aquifer levels (Freese and Nichols, Inc. 2020, p. 7-7; Far West Texas Water Planning Group 2021, p. 7-11). Increases in air temperature, and other climate-change driven variables, could affect surface water quality of spring pools and outflows by decreasing dissolved oxygen levels and increasing metal toxicity (USFWS, 2023)

Recovery

Reclassification Criteria:
Recovery Priority Number: UNK

Recovery Actions:

- No recovery plan has been written for this species.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Develop a species status assessment and recovery plan that contains measurable objectives and criteria for the Phantom springsnail. • Surveys are needed at Giffin and Phantom Lake Springs to assess species persistence and population sizes. • Research regarding the environmental tolerances (i.e., water quality parameters) of the Phantom springsnail is needed to assess the species' risk to changing habitat conditions and potential contaminants. • Continue water quantity and quality monitoring at accessible spring sites. • Maintenance and perpetuation of adequate spring flows and water quality across the San Solomon Spring system should be incorporated into local and regional water planning management strategies. Because the groundwater flow path that sustains the San Solomon Spring System underlies multiple counties, coordination among groundwater conservation districts and regional planning groups is critical to achieve this action. The effects of climate change on groundwater resources should be included in regional water planning efforts. • Examine genetic variability among populations of the Phantom springsnail to assess gene flow, population structure, and estimate population sizes. • Continue efforts to develop captive husbandry and propagation of the Phantom springsnail. Investigate the feasibility of establishing a refugia population (USFWS, 2023).

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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). As noted above, the Three Forks springsnail is a member of the genus Pyrgulopsis in the family Hydrobiidae. Springsnails are relicts of the Pleistocene Epoch (2.5 million to 10,000 years ago), an era when the Southwest was much wetter. It is one of approximately 170 known species of Hydrobiid snails in the United States, and one of 13 described species in the genus Pyrgulopsis that occur in Arizona (Hurt 2004 p. 1176). The Three Forks springsnail, initially described as Fontelicella trivialis by Taylor (1987 pp. 30– 32), was later described as Pyrgulopsis confluentis by Hershler and Landye (1988 pp. 32–35) from a spring-fed pond at Three Forks, Apache County, Arizona. The species was renamed again to Pyrgulopsis trivialis by Hershler (1994 pp. 68–69). We have carefully reviewed the available taxonomic information and conclude that P. trivialis is a valid taxon (USFWS, 2022).

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). Free-flowing springheads, concrete boxed springheads, spring runs, spring seeps, and shallow ponded water are places the Three Forks springsnail are typically found (Figure 5; Martinez and Myers 2008 p. 189). The presence of the Three Forks springsnail is associated with gravel and pebble substrates, shallow water up to 6 cm (2.4 in) deep, conductivity on average of 131.5, alkaline waters with a pH of 8, and the presence of pond snails (Physa gyrina) (Martinez and Myers 2008 pp. 189–194). Furthermore, the density of springsnails is greater in water depths less than 5.6 cm (2.2 in), in which the density of pond snails is less than 4.6 per square meter (5.5 per square yard), and where the distance from the springhead is less than 0.8 m (2.6 ft). Although research indicates that Three Forks springsnails exhibit higher density in shallower water, the species does not appear to be intolerant of deeper ponded water with flocculant mud, vegetation, and hard substrates (Taylor 1987 p. 32). The habitat features most important to the Three Forks springsnail, based on our understanding of its life history and ecology, include: 1) Adequately clean spring water (free from contamination as described above in Individual Needs) emerging from the ground and flowing on the surface; 2) Periphyton (attached algae), bacteria, and decaying organic material for food; 3) Substrates that include cobble, gravel, pebble, sand, silt, and aquatic vegetation, for egglaying, maturing, feeding, and escape from predators; and 4) Either an absence of nonnative predators (e.g., crayfish) and competitors (e.g., pond snails) or their presence at low population levels. Parameter estimates, by USFWS Science Applications, from mixed-effects hurdle model estimating number of Three Forks springsnails within springs in east-central Arizona between 2008-2020 showed that silt, hard substrate (pebble and cobble), and pH were all correlated with the presence or absence of Three Forks springsnail as shown below (USFWS, 2023).

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). Three Forks springsnail mobility is limited, given their small size and the low frequency for which significant dispersal events occur for this species. However, dispersal of aquatic snails has occurred when individual snails attached to the feathers of migratory birds (Roscoe 1955 p. 66, Dundee et al. 1967 pp. 89–90, Wesselingh et al. 1999 entire, van Leeuwen and van der Velde 2012 pp. 967–970), and stochastic events such as floods may assist with reintroductions and dispersal (Piorkowski and Diamond 2015 p. 27). Given the information available, we conclude that such dispersal events are infrequent and cannot be relied upon for site colonization or significant genetic flow (USFWS, 2023).

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

Population Growth Rate:

Rapid decline.

Number of Populations:

26 springs (USFWS, 2022).

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).   Because of the short life span of the Three Forks springsnail, abundance at a population-site can fluctuate from year to year. By plotting the last five surveyed years however, we have determined general fluctuations in abundance. We have evaluated 26 sites for Three Forks springsnail occupancy. Of these sites, none showed high condition (positive trend line with no more than one decline in abundance); seven showed moderate condition (positive trendline with two or more declines in abundance); and five showed low condition (negative trendline regardless of number of declines in abundance). The remaining sites are either considered extirpated (11) or are of unknown historical occupancy.. The current range of the Three Forks springsnail includes 26 springs and seeps along Boneyard Creek and its confluence with the North Fork and East Fork of the Black River in the White Mountains on the Apache-Sitgreaves National Forests (Figure 2). The current range can be broken up into three geographically distinct complexes: the Three Forks complex; the Boneyard Creek complex; and the Boneyard Bog complex. Each of these spring complexes occurs in shallow canyon drainages or open mountain meadows at 8,200 feet (ft) (2,500 meters [m]) in elevation. The entire range of the springsnail, encompassed within 3.7 miles (mi) (6 kilometers [km]), is along perennial waterways. This current range includes the Boneyard Bog Complex, the Boneyard Creek Complex, and the Three Forks Complex. The Three Forks complex is included despite being considered as locally extirpated since 2003 when springsnails were last documented (U.S. Fish and Wildlife Service 2012, Martinez and Sorensen 2016). The Boneyard Creek Complex includes the Lopez Spring population, with the closest haplotype to the Three Forks Complex haplotype. However, the Lopez Spring population has shown consistent signs of decline, with only one springsnail found in 2019 (USFWS, 2022)

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).

Stressor: Drought (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: The National Climate Assessment indicates that the southwestern United States will continue to get hotter and drier into the future (Garfin et al. 2014 pp. 464– 466). From 2000 to 2020, average temperatures for northeastern Arizona have differed from the long-term average by an increase of 1.4 to 1.6° F (approximately 17° C) and the region has been abnormally dry, experiencing increased moderate to severe drought conditions (U.S. EPA 2016). The Three Forks springsnail requires spring environments that have sufficient flow volume to complete their life history. Sufficient flow removes fine grain sediments, allowing for the growth of periphyton on hard substrates and providing suitable egg-laying sites. Springs are 'recharged' from two possible sources to support discharge, the first being groundwater and the second being precipitation and snowpack melt. Because springflow can be dictated by the depth to groundwater, and groundwater fluctuations, understanding the yield of groundwater-outflows can be informative. However, quantification of groundwater data for the Black River sub-basin of the Salt River-Highland Basin Hydrological Unit (Stitzer et al. 2009 p. 137) has not occurred. Wells in this sub-basin though are typically low yielding with an average depth of 500 ft (152 m). For example, a nearby well was estimated to have yields less than 100 gallons per minute (379 liters per minute) (Stitzer et al. 2009 p. 8). The Black River Sub-basin is comprised of volcanic rocks (basalt flows, rhyoltic ash flows, tuffs and tuffaceous agglomerates) with depths up to or exceeding 3,000 ft (914 m) in some areas (Stitzer et al. 2009 p. 8). Therefore, because of the porous nature of the volcanic rocks, recharge of the aquifer under this sub-basin happens through infiltration of precipitation through the ground, with the highest amount of precipitation occurring in the winter and summer. Between 1961 and 1990, the average annual precipitation was 24 to 26 inches (61-66 cm) (Stitzer et al. 2009 p. 126). Avery and Soles (Avery and Soles 2003 p. 65) found that the springs within Three Forks springsnail historical range are reliant more on precipitation and snowmelt than groundwater upwelling (USFWS, 2022).

Stressor: Wildfire (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: In the western United States, drought driven by climate change is altering natural fire regimes, with wildfires becoming more frequent, larger, and more severe (Westerling et al. 2006 pp. 940–943, Singleton et al. 2019 p. 712). In 2011, the Wallow Fire burned 217,741 ac (88,116 ha) in Arizona and New Mexico, encompassing the entire known range of the Three Forks springsnail. High severity fire burned 48% of the dry mixed-conifer forest within the Wallow Fire perimeter. This percentage is higher than the historical norm for this forest type and increases the potential for erosion and flooding (USFWS, 2022)

Stressor: Flooding (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Climate change may have effects on precipitation, discussed in "Drought" above, that are expected to alter the timing and type of precipitation received at elevations at or below 8,000 ft. This is expected to result in a more even distribution of water throughout the year. However, this could also result in increased evapotranspiration, less time and water to recharge aquifers (Longley 2017 p. 3), and potentially increased flooding because soils would be unable to sufficiently absorb precipitation before runoff occurs (Seneviratne et al. 2012 pp. 113, 118). In addition to this increased risk of flooding, there is an increased risk of erosion due to post-fire flooding caused by soils that become hydrophobic. Erosion, both from heavy rain events that result in flooding, or from rains following a higher-severity wildfire, contribute deposition of silt and sand to waterways. For aquatic species, the availability of substrate can dictate the availability of food, breeding habitat, and shelter from predators. Springsnails require hard substrates like pebbles and cobble, as well as vegetation, to adhere to for feeding, breeding, and egg laying. Too high a content of silt or sand limits the ability of springsnails to meet their dietary and reproductive needs. It is thought that high silt-sand concentrations may also impede springsnail movement, however, applicable research has not occurred. A number of factors determine silt-sand content in a spring system, but a primary factor is rate of spring flow. However, even when spring flows are adequate, an increase in silt and sand due to post-fire flooding may limit habitat suitability for the Three Forks springsnail. With increased erosion from flood waters normal flows may be inadequate to remove silt and sand, which then settle and accumulate, minimizing available hard surfaces. Because of this, a potential flood event could reduce a populations resiliency if spring flow is not sufficient to remove these fine-particulate deposits (USFWS, 2022).

Recovery

Reclassification Criteria:
Need to develop a recovery plan and reclassification criteria.

Recovery Priority Number: 2

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:

- RECOMMENDATIONS FOR FUTURE ACTIONS The establishment of a refugia population at the Phoenix Zoo is of high importance. This has proven to be an effective measure for the Huachuca springsnail and would allow for captive propagation of individual Three Forks springsnails for use in reintroduction to previously extirpated population-sites and augmentation of populations with lower abundance. Next, the continued protection of springs in the Boneyard Creek and Boneyard

Bog complexes is needed. These protections could include the installation of flashing around the perimeter of the enclosure fences already present, or the installation of both fencing and flashing for those springs that are currently without protection. Finally, we recommend the movement of boulders to be by springs that are considered to be at higher risk of flooding and silt-inundation it is the hope that these boulders could offer a buffer to any oncoming flood waters and help divert those waters and runoff materials (USFWS, 2022).

Additional Threshold Information:

-
-

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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)

Number of Populations:

4 (USFWS, 2023)

Population Size:

478 (west sandia) to 792,480 (Phantom Lake Spring) (USFWS, 2023)

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. Noreika (2019, entire), Perez et al. 2022, (pp. 85-87), and Texas Parks and Wildlife Department (2022, pp. 37-39, 58-73) investigated abundance, distribution, and/or mesohabitat associations of listed invertebrates (i.e., diminutive amphipod, Phantom springsnail, and Phantom tryonia) in the San Solomon

Spring System (i.e., East Sandia, Giffin, Phantom Lake, San Solomon, and Phantom Lake Springs). The Phantom tryonia exhibited few significant mesohabitat associations across sampled spring sites (Noreika 2019, pp. 12-14). The single habitat association noted for the species was with the presence of concrete surfaces at the San Solomon springs swimming pool (Noreika 2019, pp. 12-14; Texas Parks and Wildlife Department 2022, pp. 90, 95). 1. East Sandia Spring: 382,209 (0-1,016,600) 2. West Sandia Spring: 478 (0-1,413) 3. San Solomon Spring (canal, ciénegas, and pool combined): 53,547,058 (26,165,959-80,941,783) 4. Phantom Lake Spring: 792,480 (115,830-1,469,130)(USFWS, 2023).

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.

Stressor: Declining water quantity and degraded water quality (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: Declining water quantity and degraded water quality are the principle threats to this species (USFWS, 2020)

Recovery

Reclassification Criteria:
Recovery Priority Number: 5C

Recovery Actions:
- No recovery plan has been written for this species.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS • Develop a species status assessment and recovery plan that contains measurable objectives and criteria for the Phantom tryonia. • Surveys are needed at Giffin and Phantom Lake Springs to assess species persistence and population sizes. • Research regarding the environmental tolerances (i.e., water quality parameters) of the Phantom tryonia is needed to assess the species' risk to changing habitat conditions and potential contaminants. • Continue water quantity and quality monitoring at accessible spring sites. • Maintenance and

perpetuation of adequate spring flows and water quality across the San Solomon Spring system should be incorporated into local and regional water planning management strategies. Because the groundwater flow path that sustains the San Solomon Spring System underlies multiple counties, coordination among groundwater conservation districts and regional planning groups is critical to achieve this action. The effects of climate change on groundwater resources should be included in regional water planning efforts. • Examine genetic variability among populations of the Phantom tryonia to assess gene flow, population structure, and estimate population sizes. • Continue efforts to develop captive husbandry and propagation of the Phantom tryonia. Investigate the feasibility of establishing a refugia population (USFWS, 2023).

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Determination of Endangered Species Status for Six West Texas Aquatic Invertebrates

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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. The Gonzales tryonia inhabits the Diamond Y Spring system, a complex of isolated, desert freshwater springs, seeps, and associated ciénegas (i.e., desert wetland), in the Chihuahuan Basin and Playas ecoregion of western Texas (Taylor 1987, pp. 41-42; Veni 1991, pp. 15-17; Boghici 1997, pp. 3-4, 49-53; Griffith et al. 2004; Van Auken et al. 2007, pp. 140-144). This spring-ciénega system hosts a number of other endemic, federally-listed species including Diamond tryonia (Pseudotryonia adamantina), Leon Springs pupfish (Cyprinodon bovinus), Pecos amphipod (Gammarus pecos), Pecso assiminea (Assiminea pecos), and Pecos sunflower (Helianthus paradoxus). Bell et al. (2014, p. 30) considered the Diamond Y Spring system as among the most highly threatened aquatic systems in the Chihuahuan Desert of Texas. (USFWS, 2019)

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)

Number of Populations:

3 introduced populations (USFWS, 2020)

Population Size:

No wild individuals. ~200 reintroduced (USFWS, 2020)

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). Currently, there are no wild individuals of Hibiscadelphus hualalaiensis on the island of Hawaiʻi. Fortini et al. conducted a landscape-based assessment of climate change vulnerability for native plants of Hawaiʻi using high resolution climate change projections and their analysis showed that H. hualalaiensis is extremely vulnerable to the effects of climate change with no overlap between current and future climate envelopes. Genetic representation of the last known wild individual is complete, and collection of seeds from reintroduced plants and propagation is ongoing, with 180 plants in a living collection. Around 200 individuals have been reintroduced at three locations since the last 5-year review. High survival rates of reintroductions are observed, with recruitment of 10 naturally recruiting seedlings seen at one location (USFWS, 2020)

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).

Stressor: Oil and Gas Exploration (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Diamond Y Spring system is situated in the Delaware Basin, one the most active regions for oil and natural gas extraction activities nationally. Hydraulically fractured wells have increased to never-before-seen numbers across the region spurring increased groundwater withdrawals from local aquifers to meet drilling needs. Increased oil and natural gas drilling, production, transportation, and processing will potentially increase the risk of petroleum and/or wastewater contaminant discharges, spills, and releases. (USFWS, 2019)

Recovery

Recovery Actions:

- A recovery plan has yet to be written for this species.

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: No new threats and no other significant new information is reported regarding the species' biological status since the last 5-year review in 2015. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2020. • Surveys and inventories—Continue to conduct surveys for additional occurrences of Hibiscadelphus hualalaiensis and monitor reintroductions for a current assessment of the species' status. • Ungulate exclosures—Maintain existing exclosures and monitor for incursions by feral ungulates. • Ecosystem-altering invasive plant species control—Control invasive nonnative plants at all reintroduced populations of H. hualalaiensis. • Fire monitoring and control—Develop and implement a fire management plan for the existing reintroduction sites. • Climate change adaptation strategy—Assess the modeled effects of climate change on this species and use to determine future landscape needed for its recovery. • Predation and herbivory— o Implement effective control measures for rodents at all reintroduction sites o Research the effects of nectarrobbing by nonnative birds and determine effective control measures if determined to be necessary. o Research effects of damage caused by moths and effective control measures if determined to be necessary. • Captive propagation for genetic storage and reintroduction— o Continue collection of material for genetic storage and propagation for reintroduction. o Evaluate genetic resources currently in storage to determine the need for additional long-term storage due to this species' vulnerability to climate change. • Reintroduction and translocation—Continue reintroduction into suitable protected habitat. • Alliance and partnership development—Initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species. (USFWS, 2020)

- New Management Actions: • Captive propagation for genetic storage and reintroduction— o The rare plant nursery at Kaʻūpūlehu reports propagation of 19 plants in 2016 and 18 plants in 2019 (Kaʻūpūlehu 2019). o The rare plant nursery at Puʻuwaʻawaʻa reports propagation of 24 plants in 2018 (Puʻuwaʻawaʻa 2018). o The Volcano Rare Plant Facility (VRPF) reports propagation of 47 plants between 2015 and 2019, and collection and storage of 1,263 seeds from reintroduced plants at Puʻuwaʻawaʻa and 800 seeds from Kalopi (VRPF 2019). • Reintroduction—Currently, there are several small sites with reintroduced individuals in Puʻuwaʻawaʻa (280 individuals), and nine reintroduced in south Kohala in 2016-2017. o The rare plant nursery at Kaʻūpūlehu reports reintroduction of 18 plants at three sites at Puʻuwaʻawaʻa in 2017 (Kaʻūpūlehu 2019). o The National Tropical Botanical Garden (NTBG) reports planting of 180 individuals of H. hualalaiensis in a living collection at the Southshore Garden (NTBG 2019). o The Division of Forestry and Wildlife reports reintroduction of 24 plants within an exclosure at the Puʻuwaʻawaʻa Forest Bird Sanctuary (Puʻuwaʻawaʻa 2018). o The VRPF reports propagation of 64 plants for reintroduction at Puʻuwaʻawaʻa and nine plants at Kalopi between 2015 and 2019 (VRPF 2019). o Between 2015 and 2018, the Waimea Arboretum reports storage of six seeds (Waimea Arboretum 2015, 2017, 2018). o In 2019, the Plant Extinction Prevention Program (PEPP) reports reintroduction of 25 individuals of H. hualalaiensis in a protected area in Puʻuwaʻawaʻa; and reintroductions at Kīpuka Oweʻowe (12 individuals) and Puʻuwaʻawaʻa Cone (128 individuals) (PEPP 2019). (USFWS, 2020)

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