

SPECIES ACCOUNT: *Agave eggersiana* (No common name)

Species Taxonomic and Listing Information

Listing Status: Endangered, 10/9/2014; Southeast Region (R4) (USFWS, 2015)

Physical Description

Agave eggersiana is a flowering plant of the family Agavaceae (century plant family) with fleshy, nearly straight leaves with small marginal prickles of 0.04 inches (in) (0.1 centimeters (cm)) long that are nearly straight (Britton and Wilson 1923; Proctor and Acevedo-Rodriguez 2005). Its flowers are deep yellow and 2.0 to 2.34 in (5 to 6 cm) long. After flowering, the panicles (inflorescence) produce numerous small vegetative bulbs (bulbils), from which the species can be propagated (Proctor and Acevedo-Rodriguez 2005). *Agave eggersiana* is not known to produce fruit, and like other *Agave* species, is monocarpic, meaning the plant dies after producing the spike or inflorescence. Furthermore, based on observations of cultivated plants, *A. eggersiana* requires at least 10 to 15 years to develop as a mature individual and to produce an inflorescence (David Hamada, St. George Village Botanical Garden, pers. comm., 2010). (USFWS, 2014a)

Historical Range

Historically, *Agave eggersiana* was reported from the north coast in Christiansted, St. Croix, and along the south coast of the island (Proctor and Acevedo-Rodriguez 2005). Britton and Wilson (1923) reported the species from hillsides and plains in the eastern dry districts of St. Croix, but did not provide population estimates. In addition, it was reported that *A. eggersiana* was cultivated on St. Croix and St. Thomas for ornament (Trelease 1913; Britton and Wilson 1923; Proctor and Acevedo-Rodriguez 2005). Information provided (Kojis and Boulon, DPNR, pers. comm., 1996) specified that the species was last observed growing in the wild around 1984 to 1986 on St. Croix. Further reports until 2010 also indicated that the species appeared to be extinct (Plaskett, DPNR, pers. comm. 2003; Dalmida-Smith, DPNR, pers. comm., 2010; Proctor and Acevedo-Rodriguez, 2005). However, no citations or survey information were provided to support the apparent extinction. Subsequently, in 2010, DPNR provided information based on field visits and reported the existence of several populations of *A. eggersiana* on St. Croix (Dalmida-Smith, DPNR, pers. comm., 2010). (USFWS, 2013)

Current Range

Agave eggersiana is currently found on the north and south coasts of St. Croix, USVI. Seven populations support approximately 313 adult plants and more than 316 juveniles. The current distribution of populations of *Agave eggersiana* on St. Croix that are presumed to be wild is as follows: a. North coast—(1) Gallows Bay with an estimate of 2 individuals; and (2) Protestant Cay with an estimated 40 individuals. b. South coast—(3) Manchenil Bay with an estimated 8 individuals; (4) West side of Vagthus point with a single individual; (5) Great Pond with approximately 65 individuals; (6) South Shore with an estimate of 182 individuals; and (7) Cane Garden Bay with 15 individuals. Most of the sites have juvenile individuals except for Gallows Bay and Vagthus Point. In addition, there are introduced individuals located at Salt River National Park and Ecological Preserve (SARI) with an estimate of 90 individuals (mostly juveniles); Buck Island National Monument with an estimate of 11 individuals; and Ruth Island with 1 individual (O. Monsegur and M. Vargas, Service, pers. obs., 2010 and 2013; Dalmida-Smith, DPNR, pers. comm., 2010). (USFWS, 2013)

Critical Habitat Designated

Yes; 9/9/2014.

Legal Description

On September 9, 2014, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Agave eggersiana* under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes six critical habitat units (CHUs), in the Virgin Islands (79 FR 53315-53344).

Critical Habitat Designation

The critical habitat designation for *Agave eggersiana* includes six CHUs in St. Croix, Virgin Islands. This species critical habitat encompasses approximately 50.6 acres (ac) (20.5 hectares (ha)) (79 FR 53315-53344).

Unit 1: Cane Garden: Unit 1 consists of 6.9 ac (2.8 ha) of privately owned lands located at Estate Cane Garden and Estate Peters Mindle, Christiansted, St. Croix, USVI. This unit is located in the south-central portion of the island, approximately 0.17 mi (0.27 km) south of Road 62 and approximately 0.2 mi (0.3 km) northeast of Vagthus Point, along the northeast coast of Canegarden Bay and south of a private trail. It is within the geographical area occupied at the time of listing. This unit contains all the PCEs. The PCEs in this unit may require special considerations to address threats of nonnative plant species, effects of hurricanes (i.e., storm surge and erosion), and habitat modification (e.g., trails expansion).

Unit 2: Manchenil: Unit 2 consists of 1.5 ac (0.61 ha) of privately owned lands located at Estate Granard, Christiansted, St. Croix, USVI. This unit is located in the south-central portion of the island, approximately 0.50 mi (0.82 km) south of Road 62 and approximately 0.02 mi (0.03 km) east of South Shore Road, along the northeast coast of Manchenil Bay. It is within the geographical area occupied at the time of listing. This unit contains all the PCEs. The PCEs in this unit may require special considerations to address threats of fires, nonnative plant species, effects of hurricanes (i.e., storm surge), and habitat modification.

Unit 3: Great Pond: Unit 3 consists of 0.8 ac (0.32 ha) of territory-owned land located at Estate Great Pond, Christiansted, St. Croix, USVI. This unit is located in the south of the island, approximately 6.5 ft (2 m) south of Road 62 and east of the entrance of East End Marine Park offices. It is within the geographical area occupied at the time of listing. This unit contains all the PCEs. The PCEs in this unit may require special considerations to address threats of fire, nonnative plant species, and habitat modification (i.e., landscaping).

Unit 4: Protestant Cay: Unit 4 consists of 0.4 ac (0.16 ha) of territory-owned lands that are leased to a private party and are located at Protestant Cay, St. Croix, USVI. The Cay is located approximately 0.33 km (0.20 mi) north of Christiansted town. The unit is located on the northeast side of the Cay. It is within the geographical area occupied at the time of listing. This unit contains all the PCEs. The PCEs in this unit may require special considerations to address threats of nonnative plant species, effects of hurricanes (i.e., storm surge and erosion), and habitat modification (i.e., hotel landscaping and maintenance). The Protestant Cay unit is also currently designated as critical habitat for the St. Croix ground lizard (*Ameiva polops*) (42 FR 47840; September 22, 1977).

Unit 5: East End South: Unit 5 consists of 19 ac (7.7 ha) of privately owned lands located at Estate Jack's Bay and Estate Isaac's Bay, Christiansted, St. Croix, USVI. This unit is located south of the eastern end portion of the island, approximately 0.93 mi (1.5 km) southwest of Point Udall, approximately 0.02 mi (0.04 km) east of Point Road, along the north coast of Jack's Bay, and south of a Jack's and Issac's Bay Preserve trail. It is owned by The Nature Conservancy and managed as conservation land. This unit is not occupied at the time of listing. However, it is part of the historical range of the species. This unit is essential for the conservation of the species because it contains the PCEs and because its designation will safeguard other established populations in case of any stochastic event that occurs within habitats currently occupied by the species.

Unit 6: East End North: Unit 6 consists of 22 ac (8.9 ha) of territory-owned land located at Estate Cotton Garden, Christiansted, St. Croix, USVI. This unit is located north of the eastern end portion of the island, approximately 0.86 mi (1.4 km) northwest of Point Udall, north of Road 82 along the eastern coast of Cotton Garden Bay and western coast of Boiler Bay. This unit is not occupied at the time of listing. However, it is part of the historical range of the species. This unit is essential for the conservation of the species because it contains the PCEs and because its designation will safeguard other established populations in case of any stochastic event that occurs within habitats currently occupied by the species.

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 *Agave eggersiana* critical habitat consists of three components (79 FR 53315-53344):

- (1) Areas consisting of coastal cliffs and dry coastal shrublands. (a) Coastal cliff habitat includes: (i) Bare rock; and (ii) Sparse vegetation. (b) Dry coastal shrubland habitat includes: (i) Dry forest structure; and (ii) A plant community of predominately native vegetation.
- (2) Well-drained soils from the series Cramer, Glynn, Hasselberg, Southgate, and Victory.
- (3) Habitat of sufficient area to sustain viable populations in the coastal cliffs and dry coastal shrublands listed in PCEs (1) and (2), above.

Special Management Considerations or Protections

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. *Agave eggersiana* and *Varronia rupicola*: The primary threats to the physical or biological features (PBFs) that *Agave eggersiana* and *Varronia rupicola* depend on include: (1) Habitat destruction and modification by development; (2) competition with nonnative plant species; (3) human-induced fire; and (4) hurricanes and storm surge. The majority of these threats can be addressed by special management considerations or protection, while others (e.g., hurricanes and storm surges) are beyond the control of land owners and managers. Management activities that could ameliorate these threats include, but are not limited to, establishment of permanent conservation easements or land acquisition to protect the species and its habitat on private lands;

establishment of conservation agreements on private, nongovernment, and government lands to protect the habitat; implementation of control of invasive, nonnative plant species to reduce competition and prevent habitat degradation; implementation of management practices to control fires; and creation or revision of management plans for the identification of the areas where current developments exist and to better guide the implementation of conservation measures for the species. For *A. eggersiana*, precautions are needed to avoid inadvertent mowing and cutting of the species in the course of landscaping activities. In addition, for both *A. eggersiana* and *V. rupicola*, development of residential and tourism projects should avoid impacting these habitats directly or indirectly, and habitat fragmentation should be limited as much as possible to maintain connectivity between populations and to avoid habitat degradation due to the colonization by nonnative, invasive plants.

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Primarily vegetative (USFWS, 2014a)

Lifespan

Adult: Dies after flowering (USFWS, 2014a)

Other Reproductive Information

Adult: After flowering, the panicles (inflorescence) produce numerous small vegetative bulbs (bulbils), from which the species can be propagated (Proctor and Acevedo-Rodriguez 2005). (USFWS, 2014a)

Reproduction Narrative

Adult: Agave *eggersiana* reaches maturity and flowers after at least 10 to 15 years of growth. The pollinator for this species is unknown. The plant dies after flowering. Vegetative reproduction occurs through the development of small vegetative bulbs produced by the panicles after flowering. Because the species relies on asexual reproduction, it is dependent upon the vegetative bulbs becoming established. (USFWS, 2014a) Since *Gonocalyx concolor* was listed in 2014, little information about its biology and life history have been gathered. The species has been observed flowering in December, January, February, March, and April (Pacheco 2016, unpubl. data; Meléndez-Ackerman and Espailat 2020). Fruits have been observed in March, May, June, and July (Pacheco 2016, pers. obs.; Meléndez-Ackerman and Espailat 2020). However, no seedlings have been documented in the wild. Preliminary data from surveys conducted between January and March 2020 indicate that 28 (43.5 percent) of the 62 *G. concolor* individuals monitored at Cerro La Santa were reproductive, but, overall, the estimated average number of reproductive structures was low (1.64 ± 1.64 flowers, 2.06 ± 3.90 buds, 58 ± 1.94 fruits) (Meléndez-Ackerman and Espailat 2020). (USFWS, 2021)

Habitat Type

Adult: Terrestrial (USFWS, 2014a)

Habitat Vegetation or Surface Water Classification

Adult: Subtropical dry forest zone (USFWS, 2014a)

Dependencies on Specific Environmental Elements

Adult: Dry climate regime (USFWS, 2014b)

Geographic or Habitat Restraints or Barriers

Adult: Invasive plants (USFWS, 2014a)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2013)

Site Fidelity

Adult: High (USFWS, 2013)

Dependency on Other Individuals or Species for Habitat

Adult: Competition with nonnative plants (USFWS, 2014a)

Habitat Narrative

Adult: Agave eggersiana is endemic to the island of St. Croix in the U.S. Virgin Islands, and is currently known from coastal cliffs with sparse vegetation and dry coastal shrubland vegetation communities within the subtropical dry forest life zone of St. Croix, USVI (Ewel and Whitmore 1973). The coastal cliffs where Agave eggersiana occurs are dominated by rocky formations and areas with less than 10 percent vegetative cover. These coastal cliffs are exposed to extremes of wind, salt spray, and low moisture, and they are usually sparsely vegetated with a canopy less than 3.3 feet (ft) (1 meter (m)) in height (Gibney et al. 2000, p. 7; Moser et al. 2010, Appendix A–11). A. eggersiana plants also seem to be stressed by competition with nonnative plants. (USFWS, 2013)

Dispersal/Migration**Dispersal**

Adult: Low (inferred from USFWS, 2013)

Dispersal/Migration Narrative

Adult: Because Agave eggersiana was rediscovered only in 2010, many biological factors, including dispersal, are poorly known. (USFWS, 2013)

Population Information and Trends**Population Trends:**

Decreasing (USFWS, 2013)

Species Trends:

Decreasing (USFWS, 2013)

Population Growth Rate:

Slow (USFWS, 2013)

Number of Populations:

14 extant (both natural and introduced). 6 are considered natural(USFWS, 2022)

Population Size:

1,564 total. 490 adults, 644 young adults and >430 juveniles (USFWS, 2022)

Population Narrative:

The species initially declined as a result of sugar production and subsequently because of development. Until recently, it was last seen in the wild in 1986, and it was presumed to be extinct in the wild until 2010 when it was rediscovered. Although there are seven natural populations, most are precarious due to various kinds of development and the potential competition with invasive species. One population is in a Conservation area at Great Pond and appears to be healthy, but it is surrounded by mowed areas, an access road, and adjacent private property being sold, possibly for development. The lengthy time to maturity (10-15 years), the apparent lack of sexual reproduction, and asexual reproduction limited to post-flowering all indicate a low propensity for population increase. (USFWS, 2013). *Agave eggersiana* is a flowering plant of the family Agavaceae (century plant family) endemic to the island of St. Croix in the U.S. Virgin Islands. This species is currently found on the north and south coasts of St. Croix. Fourteen extant populations, including natural and introduced populations, support approximately 1,564 individuals, consisting of 490 adult plants, 644 young adults and more than 430 juveniles. It is uncertain if these populations are natural (individuals that come from wild populations) or if they consist of individuals that escaped from landscaping. However, since the time of listing, we have considered six of these populations to be natural (currently one presumed extirpated) (Service 2021a) since they grow mixed with native vegetation, show evidence of natural recruitment, and contain different size classes suggesting that they were remnants of wild populations. *Agave eggersiana* was listed as endangered on September 9, 2014 (79 FR 53303). The Service also designated critical habitat at the time the species was listed (USFWS, 2022)

Threats and Stressors

Stressor: Development/loss of habitat (USFWS, 2014a)

Exposure:

Response:

Consequence:

Narrative: Most populations occur within privately owned lands and are threatened by development, or are growing in areas that are already developed and managed as tourism and residential projects and that will not support the continued existence of the plants. At least three of the populations lie within areas identified by the Department of Planning and Natural Resources as high-density land use areas and thus have a high susceptibility to development in the near future. The coastal areas that harbor suitable habitat for the species are currently subject to urban and tourist development (O. Monsegur and M. Vargas, Service, pers. obs., 2010 and 2013). At least two proposed development projects have been identified within suitable habitat for the species (Weiss, CBD, pers. comm., 2010). Current information regarding the status of these projects is not available to the Service. (USFWS, 2013)

Stressor: Competition/Invasive species (USFWS, 2014a)

Exposure:

Response:

Consequence:

Narrative: Undeveloped habitat is being rapidly colonized by nonnative species. Agave eggersiana plants seem to be stressed by competition with nonnative plants. Three populations are surrounded by dense stands of different species of Sansevieria, an herb native to Africa. This invasive species seems to be occupying the ecological niche adjacent to known populations of A. eggersiana (O. Monsegur, Service, pers. obs., 2013). This invasive species can constrain the number of individuals of A. eggersiana and reduce the species' limited populations even more. (USFWS, 2014a)

Stressor: Gardening maintenance activities (USFWS, 2014a)

Exposure:

Response:

Consequence:

Narrative: The disposal of garden debris from a hotel in the species' known habitat may cover the plants (O. Monsegur and M. Vargas, Service, pers. obs., 2010). As Agave eggersiana relies on asexual reproduction, the species depends on the bulbils becoming established. Covering the bulbils with debris may result in subsequent mortality of the bulbils and lack of natural recruitment, thus affecting the long-term survival of this population. Moreover, individuals located on the edges of the population are pruned as part of the gardens' maintenance. This practice may result in mortality or mutilation of individuals because the species is monopodial (single growth axis). (USFWS, 2014a)

Stressor: Collection (USFWS, 2014a)

Exposure:

Response:

Consequence:

Narrative: Most cultivated populations are groomed, and the residents do not allow natural recruitment. Therefore, we consider collection to be a threat to the species, due to the few remaining natural populations and the demand for these plants as ornamentals. Overcollection from natural populations may compromise the natural recruitment and the recovery of Agave eggersiana. (USFWS, 2014a)

Stressor: Pathogens (USFWS, 2014a)

Exposure:

Response:

Consequence:

Narrative: The genus agave is widely affected by the agave snout weevil (Scyphophorus acupunctatus). This weevil has a wide distribution that includes the Greater Antilles (Vaurie 1971; Setliff and Anderson 2011). The larvae of this weevil feed on the starchy base of the plant, increasing the risk of infestation by pathogens such as a virus or fungus, later resulting in the death of the plant (Vaurie 1971). At this time, there is no information about the occurrence of the agave snout weevil within St. Croix, nor specifically on Agave eggersiana. However, it has been documented to be found on adjacent islands such as St. Thomas and Water Island, and we consider that the weevil's arrival to this island to be likely. The agave snout weevil's presence on nearby islands is a concern, especially considering traffic and trade among islands that could increase the risk of this weevil to arrive and infest the island at any time. (USFWS, 2014a)

Stressor: Human-induced fires (USFWS, 2014a)

Exposure:**Response:****Consequence:**

Narrative: Fire is not a natural event in subtropical dry or moist forests in the U. S. Virgin Islands. The vegetation in the Caribbean is not adapted to fires, because this disturbance does not naturally occur on these islands (Brandeis and Woodall 2008; Santiago-Garcia et al. 2008). Human-induced fires could modify the landscape by promoting nonnative trees and grasses, and by diminishing the seed bank of native species (Brandeis and Woodall 2008). (USFWS, 2014a)

Stressor: Severely restricted range (USFWS, 2022)

Exposure:**Response:****Consequence:**

Narrative: severely restricted range is a threat to this species (USFWS, 2022)

Recovery**Reclassification Criteria:**

ESTIMATED COSTS OF DELISTING: The cost to recover and ultimately delist *A. eggersiana* is estimated to be \$618,000. Some costs are not determinable at this time, and therefore the total cost of recovery may be higher than this estimate.

Recovery Priority Number: 8

Delisting Criteria:

1. The five (5) existing natural populations (South Shore, Cane Garden Bay, Manchenil Bay, Protestant Cay, and Great Pond) are protected through long-term conservation mechanisms (addresses Factors A, B, and E). 2. The five (5) existing natural populations (South Shore, Cane Garden Bay, Manchenil Bay, Protestant Cay, and Great Pond) show a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factors A and E). 3. Establish ten (10) new populations on protected areas within the historical range of the species, showing a stable or increasing population trend, evidenced by natural recruitment and multiple age classes (Addresses Factors A, C, and E). 4. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Addresses Factors A, B, C, D, and E) (USFWS, 2022).

Recovery Actions:

- 1. Protect and manage *A. eggersiana* populations and its habitat by implementing habitat management practices and other conservation mechanisms (USFWS, 2022).
- 2. Develop and implement a reintroduction plan to augment existing populations and establish new populations (USFWS, 2022).
- 3. Assess the effect of the agave snout weevil on the species and determine feasible management actions (USFWS, 2022).
- 4. Conduct genetic study on *A. eggersiana* (USFWS, 2022).
- 5. Monitor *A. eggersiana* population and its habitat (USFWS, 2022).
- 6. Facilitate recovery of *A. eggersiana* through public awareness and education (USFWS, 2022).

- 7. Refine recovery criteria and determine what additional actions are necessary to achieve recovery criteria for *A. eggersiana* (USFWS, 2022).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Finalize the recovery plan for *Gonocalyx concolor*. • Prevent further habitat loss and population decline by implementing habitat management and other conservation strategies. • Continue working with stakeholders to avoid and reduce impacts of the telecommunication facilities (particularly expansion and maintenance) to *Gonocalyx concolor* and its habitat. • Continue gathering information on the biology, ecology, distribution and abundance of *Gonocalyx concolor*. • Develop and validate a habitat suitability model to predict spatial distribution of the species and its habitat in Puerto Rico • Evaluate the species resilience to climate change and other factors. • Evaluate feasibility of a controlled propagation program for *Gonocalyx concolor*. • Evaluate feasibility of vegetative plant propagation and germination from seed. • Facilitate recovery and protection of *Gonocalyx concolor* through public awareness and education. (USFWS, 2021)

References

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016

USFWS. 2013. Endangered and Threatened Wildlife and Plants

Endangered Status for *Agave eggersiana* and *Gonocalyx concolor*, and Threatened Status for *Varronia rupicola*. Proposed rule. 78 Federal Register 204, October 22, 2013. Pages 62460-62579.

USFWS 2014a. Endangered and Threatened Wildlife and Plants

Endangered Species Status for *Agave eggersiana* and *Gonocalyx concolor*, and Threatened Species Status for *Varronia rupicola*. Final rule. 79 Federal Register 174, September 9, 2014. Pages 53303-53315.

USFWS. 2014b. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for *Agave eggersiana*, *Gonocalyx concolor*, and *Varronia rupicola*. Final rule. 79 Federal Register 174, September 9, 2014. Pages 53315-53344.

U.S. Fish and Wildlife Service. 2014. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for *Agave eggersiana*, *Gonocalyx concolor*, and *Varronia rupicola*. Final Rule. 79 FR 53315-53344 (September 9, 2014).

USFWS. 1995. Lesser Long-nosed Bat Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 45 pp. USFWS. 2021. *Gonocalyx concolor* (no common name) 5-Year Status Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf & Mississippi Basin Regions Caribbean Ecological Services Field Office Boquerón, Puerto Rico. 22 pp.

Endangered Status for *Agave eggersiana* and *Gonocalyx concolor*, and Threatened Status for *Varronia rupicola*. Proposed rule. 78 Federal Register 204, October 22, 2013. Pages 62460-62579.

USFWS. 2022. Recovery Plan for *Agave eggersiana*. South Atlantic- Gulf Regional Office, Atlanta, Georgia.

USFWS. 2014a. Endangered and Threatened Wildlife and Plants

Endangered Species Status for *Agave eggersiana* and *Gonocalyx concolor*, and Threatened Species Status for *Varronia rupicola*. Final rule. 79 Federal Register 174, September 9, 2014. Pages 53303-53315.

USFWS. 2022. Recovery Plan for *Agave eggersiana*. South Atlantic- Gulf Regional Office, Atlanta, Georgia.

USFWS. 2021. *Gonocalyx concolor* (no common name) 5-Year Status Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf & Mississippi Basin Regions Caribbean Ecological Services Field Office Boquerón, Puerto Rico. 22 pp.

SPECIES ACCOUNT: *Allium munzii* (Munz's onion)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/13/1998; Pacific Southwest (R8) (USFWS, 2015)

Physical Description

A perennial herb with a flowering stem, 1.5-3.5 dm tall, and a single, cylindrical, hollow leaf, about 1.5 times as long as the stem, arising from an underground bulb. The terminal flower cluster is composed of 10-36 white flowers that become reddish with age (NatureServe, 2015).

Taxonomy

Several former vars. of *Allium fimbriatum* of, for example, Kartesz 1994 checklist now (1999 Kartesz Floristic Synthesis) treated as distinct species: *A. abramsii*, *A. denticulatum*, *A. diabolense*, *A. munzii*, *A. purdyi*, and *A. sharsmithiae*; the remaining vars. will be *A. fimbriatum* var. *fimbriatum*, var. *mohavense*, and var. *purdyi* (NatureServe, 2015).

Historical Range

Only known from the Gavilan Plateau and Temescal Valley regions in western Riverside County, California on clay soils (U.S. Fish and Wildlife Service 2004) (NatureServe, 2015). Its historical distribution may have been within clay soils scattered throughout the entire Perris basin in western Riverside County (USFWS, 2013).

Current Range

The range of *Allium munzii* is entirely within western Riverside County, California (Figure 1). In our listing rule, we identified 13 extant occurrences of *Allium munzii* (USFWS 1998, p. 54975). Subsequently, in our 2009 5-year review, we identified 18 extant occurrences (USFWS 2009, Appendix 1 therein). In our 2013 5-year review, we identified 18 extant occurrences as well, but we also included data from herbaria collections¹ and used a different grouping methodology (see below) (USFWS 2013, pp. 8–9). Since the 2013 5-year review, we have new information that affects our understanding of the species' distribution at two locations; these changes do not affect the species' overall range (USFWS, 2022).

Critical Habitat Designated

Yes; 4/16/2013.

Legal Description

On April 16, 2013, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Allium munzii* (Munz's onion) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes six critical habitat units (CHUs) in California. In total, approximately 98.4 acres (39.8 hectares) are being designated as critical habitat for *A. munzii* (78 FR 22626-22658).

Critical Habitat Designation

The critical habitat designation for *Allium munzii* includes six CHUs in Riverside County, California (78 FR 22626-22658).

Elsinore Peak Unit Elsinore Peak Unit consists of 98.4 ac (39.8 ha). About two-thirds (63.1 ac (25.5 ha)) of the Elsinore Peak unit is contained within the Cleveland National Forest, and one-third is a 35.3- ac (14.3-ha) inholding under State of California (State Lands Commission) ownership within the Western Riverside County MSHCP Conservation Area. The Elsinore Peak Unit represents the most southwestern extent of the range of *Allium munzii* and is the highest recorded elevation (3,300 to 3,500 ft (1,006 to 1,067 m)) for this species (Boyd and Mistretta 1991, p. 3). Many of the locations of *A. munzii* found on the Cleveland National Forest portion of this unit have been described as the least disturbed of known locations (Boyd and Mistretta 1991, p. 3), and are also unusual in that they are found on cobble deposits with thinner Bosanko clay soils (PCE 2) (Boyd and Mistretta 1991, p. 3). In 1991, Boyd and Mistretta (1991, p. 2) reported three stands of *A. munzii* at Elsinore Peak, each with more than 1,000 individual plants, the largest estimated at 5,000 plants. Nine localities were observed in a 2008 survey, with populations ranging from 5 to 100 plants (K. Drennen 2011, pers. comm.). A 2010 survey at Elsinore Peak was conducted by Boyd (2011b, pers. comm.) with approximately 23 general point localities recorded on lands owned and managed by both the U.S. Forest Service and the State Lands Commission. The Elsinore Peak Unit is within the geographical area occupied at the time of listing. The subsurface and surface elements that define this subunit, including clay soils, sloping hillsides, and microhabitats, provide the physical or biological features essential to the conservation of *A. munzii*. The U.S. Forest Service and the State Lands Commission are not permittees under the Western Riverside County MSHCP. As only discretionary actions under the control of a permittee are covered activities under the Western Riverside County MSHCP, land use activities implemented by these two entities are not considered covered activities under the plan. In addition, the lands owned and managed by the State Lands Commission within this critical habitat unit are not included as part of the conceptual reserve design of the Western Riverside County MSHCP, nor are these considered PQP lands. As outlined in the Special Management Considerations or Protection section above, several threats have been identified for *Allium munzii*. For *A. munzii* populations within Elsinore Peak Unit, threats identified at the time of listing included road grading, ORV activity, and nonnative annual grasses (63 FR 54987; October 13, 1998). Recreational activity and invasive species were identified as the two main threats to *A. munzii* on U.S. Forest Service land in the 2005 Final Environmental Impact Statement prepared for the Cleveland National Forest Land Management Plan (U.S. Forest Service (USFS) 2005, p. 160). A species management guide for *A. munzii*, completed in 1992, identified a number of management actions to help alleviate these threats, including construction of fencing and barriers to protect populations from ORV activity (Winter 1992, p. 10). Fencing, including a gate, was installed to protect plant populations, and boulders were placed along the roadway leading to Elsinore Peak to restrict ORV activity and other traffic (hikers and mountain bikers) in sensitive areas. This has reduced, but not eliminated, the impacts from ORV and other recreational activities to the population of *A. munzii* plants located on U.S. Forest Service land within this critical habitat unit (M. Thomas 2011, pers. comm.). In addition to the above activities, wildfire protection, including the use of fire retardant, may also impact the physical or biological features essential to the conservation of *A. munzii*. Therefore, the essential physical or biological features on the Forest Service lands within this unit may require special management considerations or protection. For the portion of the unit located on lands managed by the State Lands Commission, the essential physical or biological features may require special management considerations or protection to address threats to *A. munzii* resulting from ORV activity or invasive, nonnative annual grasses (CNDDDB 2011a, p. 14). We are unaware of any current conservation actions being implemented for the benefit of *A. munzii* populations found on lands owned and managed by the State Lands Commission within this critical habitat unit.

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 *Allium munzii* critical habitat consists of two components in California (78 FR 22626-22658):

- (i) Clay soil series of sedimentary origin (for example, Altamont, Auld, Bosanko, Porterville), clay lenses (pockets of clay soils) of those series that may be found as unmapped inclusions in other soil series, or soil series of sedimentary or igneous origin with a clay subsoil (for example, Cajalco, Las Posas, Vallecitos): (A) Found on level or slightly sloping landscapes or terrace escarpments; (B) Generally between the elevations of 1,200 to 3,500 ft (366 to 1,067 m) above mean sea level; (C) Within intact natural surface and subsurface structures that have been minimally altered or unaltered by ground-disturbing activities (for example, disked, graded, excavated, or recontoured); (D) Within microhabitats that receive or retain more moisture than surrounding areas, due in part to factors such as exposure, slope, and subsurface geology; and (E) Part of open native or nonnative grassland plant communities and clay soil flora, including southern needlegrass grassland, mixed grassland, and open coastal sage scrub or occasionally in cismontane juniper woodlands; or
- (ii) Outcrops of igneous rocks (pyroxenite) on rocky-sandy loam or clay soils within Riversidean sage scrub, generally between the elevations of 1,200 to 3,500 ft (366 to 1,067 m) above mean sea level.

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 physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection. *Allium munzii* A detailed discussion of threats to *Allium munzii* and its habitat can be found in the final listing rule (63 FR 54975; October 13, 1998), the previous proposed and final critical habitat designations (69 FR 31569, June 4, 2004; 70 FR 33015, June 7, 2005), the *A. munzii* 5-year review signed on June 17, 2009 (Service 2009), and the proposed revised rule for designation of critical habitat (77 FR 23008; April 17, 2012). Actions and development that alter habitat suitable for the species or affect the natural hydrologic processes upon which the species depends could threaten the species. The physical or biological features essential to the conservation of *Allium munzii* all face ongoing threats that may require special management considerations or protection. Threats that may require special management considerations or protection of the physical or biological features include: (1) Loss or degradation of native plant communities, such as grassland, open coastal sage scrub, and cismontane juniper woodlands, due to urban development, agricultural activities, and clay mining (PCEs 1 and 2); (2) Disturbance of clay or other occupied soils by activities such as offroad vehicles (ORV) and fire management (PCEs 1 and 2); (3) Invasion of nonnative plant species (PCEs 1 and 2); and (4) Long-term threats including climatic variations such as extended periods of drought (PCE 1) (63 FR 54982–54986, October 13, 1998; 69 FR 31571, June 4, 2004; 70 FR 33023, June 7, 2005; Service 2009, pp. 10–22). Special management considerations or protection may be needed to ensure the long-term existence of clay soil integrity within habitats that support the physical or biological features essential to the conservation of *Allium munzii*. These include: (1) Protection of habitat from urban development or destruction to maintain integrity of clay soils, (2) Reduction of land conversion to agricultural uses and reduction of disking or dryland farming to maintain

native habitats, (3) Management and control of invasive nonnative plants to provide open areas for growth and reproduction, and (4) Land acquisition or conservation easements for occurrences not already conserved to protect those populations within occupied habitats.

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual (NatureServe, 2015); vegetative (USFWS, 2013)

Breeding Season

Adult: March - May (NatureServe, 2015)

Key Resources Needed for Breeding

Adult: Adequate rainfall (NatureServe, 2015); insect pollinators (USFWS, 2013)

Reproduction Narrative

Adult: Three to five years are needed after seeds germinate before the plant reaches sexual maturity and produces flowers. The plant is dormant for most of the year except for the spring and early summer. This species flowers from March to May. Finally, this species responds to the varied amounts of rainfall from year to year which affect its emergence. In years with little rainfall few plants flower, and in years with good rainfall most plants bloom (U.S. Fish and Wildlife Service 2004). Reproduction is sexual (NatureServe, 2015). In addition to sexual reproduction through seed production, *Allium munzii* plants can reproduce asexually through vegetative division of the bulbs (Ellstrand 1999, p. 1; Ellstrand 1993, p. 5). The Service does not have definitive information regarding pollinators of *Allium munzii*, but it is likely that a number of insect species serve this function (S. Boyd, Botanist, 2007, pers. comm.). Small beetles of the family Anthicidae (ant-like flower beetles) were found on about one-third of the *A. munzii* inflorescences of a population in Temescal Canyon (The Environmental Trust 2002, p. 16); however, their role as pollinators was not confirmed. A photograph published in a 2011 *A. munzii* monitoring report depicts what appear to be March flies (*Bibio* sp.) (*Bibionidae* family) on flowering *A. munzii* (Dudek 2011, front cover). Adult species of *Bibio* are considered important pollinators (Fitzgerald 2005, p. 17) and are frequently found on flowers (Borror and DeLong 1971, p. 501) (USFWS, 2013).

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Coastal-sage scrub (NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Occurs at 1,200 - 3,500 ft. elevation (USFWS, 2013)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Habitat Narrative

Adult: Grassy openings in coastal-sage scrub. Soils are moist, heavy clays. This species has a very narrow environmental specificity (NatureServe, 2015). It occurs between the elevations of 1,200 to 3,500 ft. (366 to 1,067 meters (m)) above mean sea level (Boyd 1988, p. 2; Boyd and Mistretta 1991, pp. 1–3; Roberts et al. 2004, pp. 10, 130) (USFWS, 2013). Plants are most frequently found in areas that are minimally disturbed and in areas where there is little competition and overcrowding from nonnative plants. *Allium munzii* is also found in rocky-sandy loam soil within rocky outcrops (such as North Domenigoni Hills) (CNDDB 2011a, Element Occurrence (EO) 10) (USFWS, 2012).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Wet clay soils facilitate the formation of soil channels for movement of young bulbs (Pu'tz 1992, p. 1433), which is necessary for establishment and persistence of *A. munzii* plants (USFWS, 2012).

Population Information and Trends**Population Trends:**

Unknown (NatureServe, 2015)

Species Trends:

10 - 70% decline (NatureServe, 2015)

Number of Populations:

15 (USFWS, 2013)

Population Size:

20,000 - 70,000 (NatureServe, 2015)

Adaptability:

Low (inferred from USFWS, 2013)

Population Narrative:

It occurs in populations usually less than 1,000 plants (U.S. Fish and Wildlife Service 2004). The long-term population trend is unknown. About 20,000 to 70,000 individuals are estimated. In response to rainfall and other factors, perennial bulbs may not produce aerial leaves or flowers in a given year or may produce only leaves. As a result, fluctuations in numbers of observed individuals may be misleading. Five populations contain over 2,000 individuals and cover as much as 8 hectares. Most populations contain fewer than 1000 individuals and their areas range from several meters to less than 1 hectare. There are ten element occurrences with good to excellent viability. This species has experienced a short-term decline of 10 - 70 % (NatureServe, 2015). The Service has defined 6 geographic locations representing 15 presumed extant occurrences of *A. munzii* in western Riverside County. This species exhibits two key attributes that might limit its distribution and population growth. These attributes include: 1) Restriction of the species to specific microhabitats (i.e., specialized niche) that have been significantly reduced in western Riverside County. 2) Dependence on undisturbed clay soils in these microhabitats

that are easily and permanently altered by human activities (USFWS, 2013). Over time, the overall number of *Allium munzii* documented occurrences we considered extant has increased from 13 in 1998 (at listing) to 18 in 2009, 2013, and currently. However, the actual number of on-the-ground occurrences should have been 17 in 2009 and 2013 because we erroneously added an EO in 2009; we no longer consider the “proposed” occurrence in the Bachelor Mountain area to be valid. In 2017, a new *Allium munzii* population was detected north of Alberhill; we consider the CNDDDB-designated EO 24 to be valid. Thus, we currently consider 18 EOs to be extant (USFWS, 2022).

Threats and Stressors

Stressor: Urban development (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: Since listing, urban development has continued in western Riverside County, including the Temescal Valley area where portions of available habitat were lost at the Sycamore Creek (EO 3) occurrence and proposed for development (Saddleback Estates) at the De Palma Road (EO 7) occurrence (Dudek 2011, p. 1; Helix Environmental Planning 2011, p. 1). However, salvage and transplant operations for *A. munzii* plants were successfully conducted at both of these project sites (see Helix Environmental Planning 2011; Dudek 2011). A 7-year maintenance and monitoring period for the De Palma Road occurrence was initiated in 2008, although construction of the proposed road and development has not been initiated (Dudek 2013, p. v). Threats from urban development have been significantly reduced since the time of listing, but are still a concern at two occurrences (Dawson Canyon and Alberhill Creek) (USFWS, 2013).

Stressor: Recreational activities (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: Dispersed recreation (e.g., camping, hiking, mountain bike activity) is an occasional, ongoing use within several *Allium munzii* occurrences. The use of existing trails or the creation of new trails within the Elsinore Peak occurrence located on CNF lands has been and continues to be a threat to *A. munzii* primarily from disturbance of habitat, although crushing or trampling of individual plants may also result from these activities (USFWS, 2013).

Stressor: Invasive plants (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: Disking and grading activities related to agriculture and urban development can promote the spread of invasive weedy grasses (Boyd 1988, p. 3), and therefore reduce the available habitat for *A. munzii*. Invasive nonnative plants were identified by USFS as a threat to habitat quality for *Allium munzii* at the Elsinore Peak occurrence (USFS 2005e, Volume 1, p. 160). Roads and road construction from grading of fuel breaks facilitate the introduction and establishment of invasive nonnative plants (discussed above) by creating open, repeatedly disturbed habitat. Invasive nonnative plants can also be transported along these corridors by equipment and other vehicles, as well as recreational activity. They are more readily established

on the exposed cut-and-fill slopes of roads than native plants (USFS 2005e, Volume 1, p. 114). Recent observations of invasive nonnative plants also include the Bachelor Mountain, Estelle Mountain, and Scott Road occurrences (Malisch 2013, pers. comm.) (USFWS, 2013).

Stressor: Fire management (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: Allium munzii habitat may be destroyed or modified during the creation and maintenance of fire breaks, a practice which often used for wildland fire management. Under the programmatic direction of the revised Land Management Plans for the four Southern California National Forests, future fuel treatments on CNF, which incorporates the Elsinore Peak occurrence, may have short-term impacts to Allium munzii, but these activities would be conducted to provide long-term benefits to the species (USFWS 2005, p. 122). The risk of wildland fire is expected to increase in western Riverside County by 2020 due to climate change effects (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: Based on the best available information contained in model predictions for this general region of California, a change in temperature conditions resulting from climate change is considered a rangewide threat to Allium munzii due to predicted changes to its habitat. Climate model predications also indicate a moderate increase in fire risk to the geographical range of A. munzii, which, when combined with anthropogenic facilitation, can produce a shortening of the fire return interval and potentially increase wildland fire management practices, such as the creation of fuel breaks, which can disturb native soils (USFWS, 2013).

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Recovery Priority Number: 8C

Delisting Criteria:

Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Continue to work with CNF to ensure that USFS guidelines and directives are being implemented for activities that might directly or indirectly affect Allium munzii habitat. This should also include providing comment on biological assessments for proposed recreational and trail use and maintenance and proposed wildland fire management actions (USFWS, 2013).
- Survey current, presumed extant occurrences of Allium munzii to estimate the level and extent of nonnative invasive plants. Develop site-specific restoration measures such as

- thatch removal or prescribed fire (USFWS, 2013).
- Continue to conserve or preserve *Allium munzii* occurrences on private lands, especially within the Temescal Valley occurrences. Pursue opportunities to purchase parcels through the Act's section 6 funding and other conservation partnership programs (i.e., Western Riverside County MSHCP) with willing sellers (USFWS, 2013).
 - Identify pollinators of *Allium munzii* by installing small trigger cameras to record and document pollinators at the occurrence at Elsinore Peak, Cleveland National Forest (USFWS, 2013).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Conduct recovery planning. Currently, there is no recovery plan for *Allium munzii*. In the interim, the Carlsbad and Palm Springs Fish and Wildlife Offices should develop recovery guidance documents, such as a Species Action Plan. Recovery guidance documents should address the observed low genetic diversity among *Allium munzii* EOs, as recommended by Mashayekhi and Columbus (2015, pp. 96–97). 2. Continue to work with partners, including the Western Riverside County RCA and the Cleveland National Forest, to (a) acquire land needed to fully conserve two EOs in particular, EO 2 (highest priority) and EO 13; and (b) to monitor and manage these two EOs, which are known to have the highest *Allium munzii* abundance and, for EO 2, the highest genetic diversity. 3. Work with partners to research whether translocation or population augmentation activities would be appropriate and beneficial for *Allium munzii*. The low genetic diversity recorded by Mashayekhi and Columbus (2015, entire) suggests that, without intervention, *Allium munzii* EO-level populations may decline even if they are on conserved lands. 4. Work with partners to better define *Allium munzii* habitat needs, especially soils, and delineate (at a fine scale) occupied and unoccupied areas that meet those needs throughout the species' range. This information may (a) help find new, naturally occurring populations of *Allium munzii*; and (b) provide options for future *Allium munzii* translocation efforts to increase the number of EO-scale populations. 5. Work with partners to research *Allium munzii* pollinator species. A better understanding of *Allium munzii* pollinators could improve habitat management and may lead to more options for managing *Allium munzii* genetic diversity (USFWS, 2022).

References

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

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016

USFWS 2013. *Allium munzii* (Munz's Onion) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, California. USFWS. 2022. *Allium munzii* (Munz's onion) 5-year Review: Summary and Evaluation. Carlsbad Fish and Wildlife Office, Carlsbad, California. 12 pp.

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants

Revised Designation of Critical Habitat for *Allium munzii* (Munz's Onion) and *Atriplex coronata* var. *notatior* (San Jacinto Valley Crownscale)r. Final rule. 78 FR 22626-22658 (April 16, 2013).

USFWS 2013. *Allium munzii* (Munz's Onion) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, California

USFWS 2012. Endangered and Threatened Wildlife and Plants

Designation of Revised Critical Habitat for *Allium munzii* (Munz's onion) and *Atriplex coronata* var. *notatior* (San Jacinto Valley crownscale)

Proposed Rule. 77 Federal Register 74. April 17, 2012. Pages 23008 - 23057.

USFWS. 2013. *Allium munzii* (Munz's Onion) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, California.

USFWS 2013. *Allium munzii* (Munz's Onion) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, California.

USFWS. 2022. *Allium munzii* (Munz's onion) 5-year Review: Summary and Evaluation. Carlsbad Fish and Wildlife Office, Carlsbad, California. 12 pp.

SPECIES ACCOUNT: *Alopecurus aequalis* var. *sonomensis* (Sonoma alopecurus)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/21/1997; Pacific Southwest (R8)

Physical Description

A tufted perennial grass, 3-7.5 dm tall (NatureServe, 2015). *Alopecurus aequalis* var. *sonomensis* grows from 30 to 75 centimeters (12 to 30 inches) tall. The stems are mostly erect and either straight or weakly bent near the base. The leaf blades are up to 7.5 millimeters (0.3 inch) wide. The panicle is 2.5 to 9.0 centimeters (1.0 to 3.5 inches) long and 4 to 8 millimeters (0.1 to 0.3 inch) wide. The spikelets are usually tinged violet-gray near the tip. The awn is straight, and exceeds the lemma body by 1.0 to 2.5 millimeters (0.04 to 0.1 inch) (USFWS, 2011).

Taxonomy

Recognized as distinct by Kartesz (1999 Synthesis) and by U.S. Fish and Wildlife Service (federal listing as endangered). Kartesz treatment is based on unpublished work by Mary Barkworth for the forthcoming Grass Manual (Kartesz, pers. comm. to Larry Morse, 25Nov99). However, Crins (1993), i.e. Hickman (1993), does not recognize the variety as distinct (NatureServe, 2015). It belongs in the Poaceae (grass family) (USFWS, 2011).

Historical Range

Historically, *Alopecurus aequalis* var. *sonomensis* was known from 16 populations in Marin and Sonoma Counties (USFWS, 2011).

Current Range

The plant occurs in freshwater marshes and swamps and riparian scrub within Marin and Sonoma Counties, California (California Natural Diversity Database (CNDDB) 2011) (USFWS, 2011).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual, vegetative (USFWS, 2011)

Breeding Season

Adult: May - August (USFWS, 2011)

Reproduction Narrative

Adult: While the reproductive mechanisms of this species have not been studied, *Alopecurus aequalis* var. *sonomensis* appears to reproduce both sexually (assumed via wind pollination) and

vegetatively (via rhizomes) (Gennet 2004). Flowering begins in mid - May and lasts through August (Gennet 2004) (USFWS, 2011).

Habitat Type

Adult: Wetland (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Permanent freshwater marshes (NatureServe, 2015); swamp, riparian scrub (USFWS, 2011)

Dependencies on Specific Environmental Elements

Adult: Disturbance (NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Occurs at 10 - 1,180 ft. elevation (USFWS, 2011)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Moist soils in permanent freshwater marshes. It appears to benefit from disturbance; for example, at Point Reyes National Seashore, this plant has disappeared in areas where grazing has been removed (J. DiGregoria pers. comm. 2009) (NatureServe, 2015). All populations occur in moist soils in permanent freshwater marshes and swamps or riparian scrub between 10 and 1,180 feet in elevation (USFWS, 2011).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Not available

Number of Populations:

6 (USFWS, 2011)

Population Size:

200 (NatureServe, 2015)

Population Narrative:

There are 200 plants total. Historically, the number of individuals in populations of this taxon have varied greatly between years; for instance the largest recorded was 600 plants in 1995 and in 1996 there were only 100 (USFWS 1997) (NatureServe, 2015). Five of six known populations are clustered within a 12-square kilometer (4.6-square mile) area on the Point Reyes Peninsula in Marin County (USFWS, 2011).

Threats and Stressors

Stressor: Change in land use (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: The primary threats to *Alopecurus aequalis* var. *sonomensis* were habitat destruction and modification due to urbanization, land use changes, or alterations in hydrology. We noted that a portion of the historical range of *A. aequalis* var. *sonomensis* was within the project boundaries of a wastewater treatment facility (Service 1997). The majority of the historical populations of *Alopecurus aequalis* var. *sonomensis* experienced dramatic human-influenced land use changes prior to their decline or extirpation. Some wetland areas had been drained or altered in preparation for the construction of structures or buildings; others were fenced and intensively grazed (CNDDDB 2002; Gennet 2004) (USFWS, 2011).

Stressor: Invasive species (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: Threats to *Alopecurus aequalis* var. *sonomensis* under Factor E included competition from invasive emergent wetland species, including *Juncus* spp. (rushes) and *Cyperus* spp. (nutsedges) at one location. Competition from native invasive emergent wetland species currently impacts *Alopecurus aequalis* var. *sonomensis* at two populations. In addition, *Holcus lanatus* potentially threatens *A. aequalis* var. *sonomensis* at one location (PRNS 2006). (USFWS, 2011)

Stressor: Stochastic events (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: *Alopecurus aequalis* var. *sonomensis* has six currently known extant populations. The combination of few populations, small range, and restricted habitat makes this species highly susceptible to extinction or extirpation from a significant portion of its range due to random events, such as flood, drought, disease, or other occurrences (Shaffer 1981; Primack 2006). *Alopecurus aequalis* var. *sonomensis* is considered by NPS resource management staff and CNPS botanists as one of the taxa at greatest risk of extinction on PRNS due the low number of populations and the high degree of interannual census fluctuations (Gennet 2004) (USFWS, 2011).

Stressor: Genetic diversity (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: Small populations may also be subject to increased genetic drift and inbreeding (Menges 1991; Ellstrand and Elam 1993). Populations that are continually small in size are particularly susceptible to genetic changes due to drift. However, drift may also cause genetic changes with populations that occasionally fluctuate to small sizes (e.g., undergo population

bottlenecks). Increased homozygosity resulting from genetic drift and inbreeding may lead to a loss of fitness (ability of individuals to survive and reproduce) in small populations. In addition, reduced genetic variation in small populations may make any species less able to successfully adapt to future environmental changes (Ellstrand and Elam 1993). The extant occurrences of *Alopecurus aequalis* var. *sonomensis* includes populations, which have been observed to dip below 200 individuals (USFWS, 2011).

Stressor: Climate change (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: Climate is predicted to change in California during the 21st century (Field et al. 1999; Cayan et al. 2005). Even modest changes in warming could result in a reduction of the spring snowpack, earlier snowmelt, and more runoff in winter with less runoff in spring and summer, more winter flooding, and drier summer soils (Field et al. 1999; Cayan et al. 2005). The predicted impacts on California's ecosystems projected with a high certainty include higher sea level; decreased suitable habitat for many terrestrial species as climate change intensifies human impacts; and increased competition among urban, agricultural, and natural ecosystem uses (Field et al. 1999). Although the specific effects of climate change on *Alopecurus aequalis* var. *sonomensis* are unknown, the effects of increased winter flooding and drought conditions in the spring have the potential to adversely affect this species (USFWS, 2011).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: At the time of listing, regulatory mechanisms thought to provide inadequate protection for *Alopecurus aequalis* var. *sonomensis* included: (1) the California Environmental Quality Act (CEQA); and (2) the Clean Water Act. The listing rule (Service 1997) provides an analysis of the level of protection that was anticipated from those regulatory mechanisms. This analysis appears to remain currently valid for the CEQA, but not for the Clean Water Act. There are several State and Federal laws and regulations that are pertinent to federally listed species, each of which may contribute in varying degrees to the conservation of federally listed and non-listed species. These laws, most of which have been enacted in the past 30 to 40 years, have greatly reduced the threat of wholesale habitat destruction. The Endangered Species Act is the primary Federal law that provides protection for this species since its listing as endangered in 1992. Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Endangered Species Act. (USFWS, 2011)

Stressor: Disease or predation (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: At the time of listing, we reported that 7 of the 8 known sites of *Alopecurus aequalis* var. *sonomensis* were currently grazed or had been grazed in recent years by cattle (CNDDB

1996; V. Norris, in litt. 1995; R. Soost, in litt. 1996). We stated that some grazing may be necessary to maintain populations of *A. aequalis* var. *sonomensis* in the face of competition from other plants, but that excessive grazing by cattle can adversely impact the species (Service 1997). Too much or too little grazing may be detrimental to a population. For example, PRNS Population 1 was extirpated within three years after grazing cessation at the site (Shook pers. comm. 2001 in Gennet 2004). Conversely, the number of reproducing tillers at PRNS Population 5 was reduced by 90 percent in June 2001 after cattle were released onto the site (Gennet 2004). Tillers are shoots that are capable of producing a new plant. Both heavy grazing and exclusion from grazing can adversely affect the species. Overgrazing of foliage could limit the plant's ability to photosynthesize, which could result in death or diminished reproductive output. Consumption of inflorescence or seed could reduce the genetic variability of plants within a given population and could decrease the overall reproductive output of the individual plant. However, grazing may reduce competition from more abundant or invasive species. All natural populations of *Alopecurus aequalis* var. *sonomensis* within the PRNS are currently managed by grazing (Service 2002). The population at Annadel State Park is the only known natural population not maintained by grazing. Grazing activities may additionally result in trampling of individual plants, soil compaction, and impacts which may influence presence of invasive species (see Factor E). (USFWS, 2011)

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Delisting Criteria:

Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Conduct grazing studies to investigate the effects of trampling, soil churning and compaction, direct removal of shoot and reproductive tissue of *Alopecurus aequalis* var. *sonomensis* plants by cattle, and timing and duration of grazing. An improved understanding of the mechanisms and magnitudes of impacts to *Alopecurus aequalis* var. *sonomensis* plants and populations by cattle grazing would help ranchers and resource managers determine optimal timing, duration, and intensity of grazing (USFWS, 2011).
- Conduct surveys to try to locate additional natural occurrences of *Alopecurus aequalis* var. *sonomensis* (USFWS, 2011).
- Continue attempt to isolate factors controlling the size and viability of *Alopecurus aequalis* var. *sonomensis* populations including: (a) timing and duration of grazing, (b) timing and quantity of precipitation, (c) temperature patterns, and (d) groundwater regimes (USFWS, 2011).
- Conduct a site assessment study to improve potential success of future *Alopecurus aequalis* var. *sonomensis* populations (USFWS, 2011).

References

USFWS. 2011. *Alopecurus aequalis* var. *sonomensis* (Sonoma alopecurus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. Sacramento, California. 21 pp. September 8, 2011.

https://ecos.fws.gov/docs/five_year_review/doc3898.pdf

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

USFWS 2011. *Alopecurus aequalis* var. *sonomensis* (Sonoma alopecurus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California.

SPECIES ACCOUNT: *Aristida chaseae* (No common name)

Species Taxonomic and Listing Information

Listing Status: Endangered; 4/27/1993; Southeast Region (R4) (USFWS, 2015)

Physical Description

A perennial grass with densely tufted, wide-spreading culms which may reach from 50 to 60 centimeters in length. The leaf blades are involute, 2 to 3 mm wide and 10 to 15 mm long. The panicles are narrow and may be from 10 to 14 mm in length (USFWS, 1994).

Taxonomy

This species is in the family Poaceae (USFWS, 1994).

Historical Range

The perennial endemic grass *Aristida chaseae* (Family Poaceae), was discovered in 1913 by Agnes Chase near the ward Boquerón, in the municipality of Cabo Rojo, Puerto Rico (USFWS 1995; USFWS, 2010).

Current Range

Known from two sites: the CRNWR and the upper slopes of the Cerro Mariquita in Sierra Bermeja. (USFWS, 2010). *A. chaseae* is known from close to 500 individuals in a narrow strip in the CRNWR, approximately 600 individuals at Peñones de Melones and from an undetermined number of individuals at the rocky, exposed upper slopes of Cerro Mariquita in the Sierra Bermeja. Pelos del diablo is considered “not uncommon” on the Sierra Bermeja, but limited to rocky, exposed upper slopes of Cerro Mariquita mountain range. In recent years, pelos del diablo has not been observed at the historic site known as Cerro Las Mesas in the municipality of Mayagüez. However, based on the information currently available to us the current range of pelos del diablo includes Puerto Rico and Cuba. (USFWS, 2019). Within Cerro Mariquita, the species are known to occur at La Tinaja Tract, which is part of the Laguna Cartagena National Wildlife Refuge (LCNWR). The highest point of La Tinaja Tract lies a few meters below Cerro Mariquita peak (Weaver and China, 2003), borders to the west with a private land known as the Lozada Farm, and on the east with the private land known as Finca María Luisa (also known as Finca Escabí) (Figure 1). Most of the recorded plants are located on the western half of La Tinaja Tract, and a small amount were recorded on the southeast part on exposed rock of slopes and ridges (Morales-Perez, 2013). During 2014 and 2016, Service biologists and personnel from the FTBG visited Finca Maria Luisa (Figure 1) and found a new population of *A. chaseae* and *A. portoricensis* on the northern section of this property, which is under a conservation easement with the conservation organization Para La Naturaleza (PLN 2014), but where agricultural practices are still being conducted (Lange et al. 2017). In addition, a “robust” new population of *A. chaseae* and *A. portoricensis* were documented at Finca Solins (also known as El Conuco; Figure 1), another private property also located in the Sierra Bermeja mountains and owned by PLN (PLN 2014). In 2010, Service biologists C. Pacheco and O. Monsegur visited Peñones de Melones in the municipality of Cabo Rojo and recorded 578 individuals of *A. chaseae* in an area of approximately 275 squares meters (Figure 2) (USFWS 2010). The Peñones de Melones area is composed mainly of private lands and was once the site of the proposed Monte Carlo Resort – Boquerón Bay Villas (FWS Project identification number 72023-023), and Punta del Sol Hotel (FWS Project identification number 72023-085). (USFWS, 2019).

Critical Habitat Designated

Yes;

Life History**Food/Nutrient Resources****Reproduction Narrative**

Adult: Pollination mechanisms are probably abiotic (EPA, 2016).

Habitat Type

Adult: Terrestrial (EPA, 2016)

Habitat Vegetation or Surface Water Classification

Adult: Subtropical dry forest (EPA, 2016)

Geographic or Habitat Restraints or Barriers

Adult: ~492 - 984 ft. elevation (USFWS, 1994)

Spatial Arrangements of the Population

Adult: Clumped (USFWS, 2010)

Habitat Narrative

Adult: *Aristida chaseae* is known from two sites: the Cabo Rojo National Wildlife Refuge in the municipality of Cabo Rojo and the upper slopes of the Sierra Bermeja in the municipalities of Lajas and Cabo Rojo at elevations which range between 150 and 300 meters (McKenzie et al. 1989; Proctor 1991). At the Refuge site, the population has been estimated at 150 to 175 plants. No estimate is currently available on the species in the Sierra Bermeja due to the recent prolonged drought. (USFWS, 1994). The species seems to be in favor of clumped pattern distribution (USFWS, 2010).

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Not available

Species Trends:

Improving (USFWS, 2010)

Number of Populations:

2 (see current range/distribution)

Population Size:

> 1,000 (inferred from USFWS, 2010)

Population Narrative:

The species status is improving. In 2010, Service biologist conducted a rapid status assessment on the species at the CRNWR and Peñones de Melones providing an estimate of around 474 plants at the CRNWR and at around 578 plants at Peñones de Melones (USFWS 2010, unpublished data). Population estimates on *A. chaseae* at the Cerro Mariquita are not available. The species shows a very limited spatial distribution (USFWS, 2010).

Threats and Stressors

Stressor: Habitat modification and destruction (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Although the Cerro Mariquita area was classified by the Puerto Rico Planning Board as a District of Conservation Resource 1 (CR1) (the most restrictive for development, precluding tourist and residential development and mining activities), this classification allows agricultural (e.g. cattle grazing) and rural developments (one house in 25 acres of land). In 2006 and 2007, private landowners cut new roads to gain access through their properties to the peak of Cerro Mariquita affecting indeterminate amount of habitat for these species (Pacheco, USFWS 2009, field observations). *A. chaseae* population at Peñones de Melones is found on a site that may be affected by the proposed projects called Monte Carlo Resort – Boquerón Bay Villas (FWS Project Identification Number 72023-023) and Punta del Sol Hotel (FWS Project Identification Number 72023-085). The Punta Melones and Peñones de Melones area are currently under development pressure. According to the field observations conducted by the author of this review; the Punta Melones and the Peñones de Melones area has been impacted by residential and tourist development, and by agricultural practices such as cattle and goat grazing (USFWS, 2010).

Stressor: Introduced species (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: *A. chaseae* is currently threatened by competition from introduced grasses and forbes (e.g. legumes). The disappearance of *A. chaseae* from the type locality in Boquerón was apparently due to competition from vigorous, introduced grass species (McKenzie et al. 1989; USFWS 1993; USFWS 1995). McKenzie et al. (1989) suggested that the restricted distribution of this species on exposed, rocky areas of Sierra Bermeja was related to competition from introduced grasses. The population of *A. chaseae* at the CRNWR is limited to a narrow strip approximately 100m (328 ft) long on both sides and down the center of a dirt trail. There are dense stands of guinea grass on both sides of the population (USFWS, 2010).

Stressor: Fire (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: The species is found on exposed and scrub woodland within the driest part of the top of Cerro Mariquita. This area is susceptible to human-induced catastrophic events such as fires. Fire has frequent occurrence in this extremely dry portion of the Southwestern Puerto Rico. The rapid growth of exotic grasses on areas where this species occurs is a threat because of

competition and represent an increase in fuel that may increase the impact of fire. Because so few individuals are known to occur in a limited area, the risk of extinction is extremely high. Although the Service and Puerto Rico Fire Department implements a fire-prevention and management program during the dry season, human-induced fires are still a problem during the dry season (USFWS, 2010).

Recovery

Reclassification Criteria:

1. The known populations on privately owned land in Sierra Bermeja are placed under protective status (USFWS, 2010).
2. New populations (the number of which should be determined following the appropriate studies) capable of self-perpetuation have been established within protected areas, such as the Cabo Rojo National Wildlife Refuge (USFWS, 2010).

Delisting Criteria:

Not available

Recovery Actions:

- Conduct propagation and enhance existing populations or establish new ones on protected lands (USFWS, 1994).
- Protect habitat and existing populations, through an agreement with private landowners, the municipalities of Cabo Rojo and Lajas and the Department of Natural and Environmental Resources or through acquisition (USFWS, 1994).
- Develop and implement management plan for *A. chaseae* on Refuge land (USFWS, 1994).
- Monitor known populations (USFWS, 1994).
- Enforce existing Commonwealth and Federal endangered species regulations (USFWS, 1994).
- Educate the public on conservation values and regulations (USFWS, 1994).
- Conduct research on aspects of the life history of the species and evaluate propagation techniques (USFWS, 1994).
- Protection of currently known natural populations occurring on privately owned lands by establishing long-term conservation mechanisms such as Habitat Conservation Plans (HCP), conservation easements and conservation agreements with the landowners. (USFWS, 2019).
- Develop conservation and management plans with landowners that includes education on species description and needs and fire management. (USFWS, 2019)
- Establishment of new populations on protected lands within the Sierra Bermeja or other suitable habitats in southwestern Puerto Rico. (USFWS, 2019).
- Revise the recovery plans to include new information on the species and the development of measurable criteria for delisting the species (USFWS, 2010).
- Conduct comprehensive surveys of these four species at Sierra Bermeja to determine relative abundance and distribution (USFWS, 2010).
- Conduct surveys at Punta Melones and Peñones de Melones to determine the status of *A. chaseae* at these areas (USFWS, 2010).
- Promote Conservation agreements with private landowners to protect and enhance existing populations (USFWS, 2010).

- Initiate propagation programs for these species to enhance existing populations in the Sierra Bermeja mountain range and establish new populations of *A. chaseae* and *pelos del diablo* in protected areas in southwestern Puerto Rico (USFWS, 2010).
- Work closely with private landowners in the Sierra Bermeja mountain range and Peñones de Melones to protect individuals on private lands from existing agricultural practices and control exotic grasses (USFWS, 2010).
- Implement fire prevention practices in Sierra Bermeja, CNRWR and Peñones de Melones during dry season (USFWS, 2010).
- Continue to provide technical assistance to Service's Refuge Division for the development of the CCPs for CRNWR and LCNWR and to address current threats within the refuge (USFWS, 2010).
- Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of the species in the wild (USFWS, 2010).
- Determine the number of self-sustainable populations needed to delist the species (USFWS, 2010).
- Additional surveys should be conducted for the species in Puerto Rico (USFWS, 2010).
- Continue protecting existing populations and their habitat (USFWS, 2010).

Conservation Measures and Best Management Practices:

- Future Recommended Recovery Actions ☐ Protection of currently known natural populations occurring on privately owned lands by establishing long-term conservation mechanisms such as Habitat Conservation Plans (HCP), conservation easements and conservation agreements with the landowners. ☐ Develop conservation and management plans with landowners that includes education on species description and needs and fire management. ☐ Establishment of new populations on protected lands within the Sierra Bermeja or other suitable habitats in southwestern Puerto Rico. (USFWS, 2019)

References

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016.

USFWS 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (*pelos del diablo*) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office Boquerón, Puerto Rico

USFWS 1994. *Aristida chaseae*, *Lyonia truncata* var. *proctorii*, and *Vernonia proctorii* Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 21 pp.

USFWS. 2019. *Aristida chaseae* (no common name), *Aristida portoricensis* (*pelos del diablo*), *Lyonia truncata* var. *proctorii* / (no common name), *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. USFWS, Southeast Region, Boqueron, Puerto Rico. 35 pp.

U.S. Fish and Wildlife Service. 1994. *Aristida chaseae*, *Lyonia truncata* var. *proctorii*, and *Vernonia proctorii* Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 21 pp

USFWS 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office Boquerón, Puerto Rico.

USFWS. 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office Boquerón, Puerto Rico.

USFWS. 2019. *Aristida chaseae* (no common name), *Aristida portoricensis* (pelos del diablo), *Lyonia truncata* var. *proctorii* / (no common name), *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. USFWS, Southeast Region, Boqueron, Puerto Rico. 35 pp.

USFWS 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office, Boquerón, Puerto Rico.

USFWS. 2019. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office Boquerón, Puerto Rico. 35 pp.

SPECIES ACCOUNT: *Aristida portoricensis* (Pelos del diablo)

Species Taxonomic and Listing Information

Listing Status: Endangered; 8/8/1990; Southeast Region (R4) (USFWS, 2015)

Physical Description

The culms may reach 30-50 cm in height. The culms occur in large bunches and are slender, erect, or spreading at the base. (USFWS, 1994)

Taxonomy

Not available

Historical Range

At the time of listing, *A. portoricensis* was known from only two localities: at Cerro Mariquita in Sierra Bermeja and at Cerro Las Mesas in Mayagüez, both localities are in Puerto Rico (USFWS, 2010).

Current Range

A. portoricensis is not endemic to Puerto Rico and its current range of the species includes Puerto Rico and Cuba. Pelos del diablo is currently known from Cerro Mariquita in Sierra Bermeja. Pelos del diablo has not been observed at the historic site known as Cerro Las Mesas. (USFWS, 2010). Within Cerro Mariquita, the species are known to occur at La Tinaja Tract, which is part of the Laguna Cartagena National Wildlife Refuge (LCNWR). The highest point of La Tinaja Tract lies a few meters below Cerro Mariquita peak (Weaver and Chineá, 2003), borders to the west with a private land known as the Lozada Farm, and on the east with the private land known as Finca María Luisa (also known as Finca Escabi) (Figure 1). Most of the recorded plants are located on the western half of La Tinaja Tract, and a small amount were recorded on the southeast part on exposed rock of slopes and ridges (Morales-Perez, 2013). During 2014 and 2016, Service biologists and personnel from the FTBG visited Finca Maria Luisa (Figure 1) and found a new population of *A. chaseae* and *A. portoricensis* on the northern section of this property, which is under a conservation easement with the conservation organization Para La Naturaleza (PLN 2014), but where agricultural practices are still being conducted (Lange et al. 2017). In addition, a “robust” new population of *A. chaseae* and *A. portoricensis* were documented at Finca Solins (also known as El Conuco; Figure 1), another private property also located in the Sierra Bermeja mountains and owned by PLN (PLN 2014). Also, during 2014 and 2016, personnel from the FTBG visited a private property named Upper Rancho Hugo in the Sierra Bermeja mountains. According to Lange et al. (2017), here they documented the healthiest population of *A. portoricensis* of all the areas they had visited in Sierra Bermeja in 2016. In 2016, Service biologist C. Pacheco also conducted a rapid assessment for *A. portoricensis* in this property, and counted 970 individuals in one acre. This private property is located just southeast of El Conuco. In 2018, botanists from UPRM documented the presence of *A. portoricensis* on a private property at Cerro Las Mesas in the municipality of Mayagüez that is suspected to be the type locality for the species (Figure 2) (58 FR 32255; final listing rule). (USFWS, 2019).

Critical Habitat Designated

Yes;

Life History**Food/Nutrient Resources****Reproductive Strategy**

Adult: Sexual (inferred from EA, 2016)

Breeding Season

Adult: September - November (EPA, 2016)

Key Resources Needed for Breeding

Adult: Abiotic factors - not specified (EPA, 2016)

Reproduction Narrative

Adult: Flowering occurs September - November. Pollination mechanisms are probably abiotic (EPA, 2016).

Habitat Type

Adult: Terrestrial (EPA, 2016)

Habitat Vegetation or Surface Water Classification

Adult: Subtropical wet forest, savannah, subtropical dry forest (EPA, 2016)

Geographic or Habitat Restraints or Barriers

Adult: ~590 - 1148 ft elevation (EPA, 2016)

Environmental Specificity

Adult: Broad (inferred from EPA, 2016)

Habitat Narrative

Adult: Occurs in Cerro las Mesas in the subtropical wet forest life zone. Also occurs in natural savannah dominated by grasses and herbaceous vegetation. Sierra Bermeja: grows on exposed rocky outcrops and openings; subtropical dry forest life zone. Habitats located in Cerro Las Mesas and Sierra Bermeja on serpentine slopes and red clay soils in southwestern Puerto Rico. Restricted to upper exposed slopes of Cerro Mariquita in Sierra Bermeja. Occurs at elevations between 590 to 1148 ft. Serpentine slopes and red clay soils. Cerro las Mesas site: Nipe clay (deep well-drained soils, primarily located on mesa-like ridgetops, which were formed from serpentine-derived material) is extremely weathered and of low fertility. Sierra Bermeja site: Guayama cherty loam (EPA, 2016).

Dispersal/Migration**Dependency on Other Individuals or Species for Dispersal**

Adult: Bird and mammal dispersal vectors (EPA, 2016)

Dispersal/Migration Narrative

Adult: Dispersal mechanisms are probably abiotic and biotic (bird, mammal) (EPA, 2016).

Population Information and Trends**Population Trends:**

Not available

Species Trends:

Stable (USFWS, 2010)

Number of Populations:

2 (see current range/distribution)

Population Size:

Not available (USFWS, 2010)

Population Narrative:

The species status is stable; over the past year, no changes in the species' status were reported. Population estimates on pelos del diablo at the Cerro Mariquita are not available (USFWS, 2010).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Although the Cerro Mariquita area was classified by the Puerto Rico Planning Board as a District of Conservation Resource 1 (CR1) (the most restrictive for development, precluding tourist and residential development and mining activities), this classification allows agricultural (e.g. cattle grazing) and rural developments (one house in 25 acres of land). In 2006 and 2007, private landowners cut new roads to gain access through their properties to the peak of Cerro Mariquita affecting indeterminate amount of habitat for this species (Pacheco, USFWS 2009, field observations) (USFWS, 2010).

Stressor: Introduced species (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Pelos del diablo is currently threatened by competition from introduced grasses and forbes (e.g. legumes). McKenzie et al. (1989) suggested that the restricted distribution of this species on exposed, rocky areas of Sierra Bermeja was related to competition from introduced grasses (USFWS, 2010).

Stressor: Fire (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Pelos del Diablo is found on exposed and scrub woodland within the driest part of the top of Cerro Mariquita. This area is susceptible to human-induced catastrophic events such as fires. Fire has frequent occurrence in this extremely dry portion of the Southwestern Puerto Rico. The rapid growth of exotic grasses on areas where the species occurs is a threat because of competition and represent an increase in fuel that may increase the impact of fire. Because so few individuals are known to occur in a limited area, the risk of extinction is extremely high. Although the Service and Puerto Rico Fire Department implements a fire-prevention and management program during the dry season, human-induced fires are still a problem during the dry season (USFWS, 2010).

Recovery

Reclassification Criteria:

Not available

Delisting Criteria:

1. The known population on privately owned land in Sierra Bermeja is placed in protective status (USFWS, 2010).
2. An agreement between the Fish and Wildlife Service, Soil Conservation Service, and the University of Puerto Rico has been prepared and implemented (USFWS, 2010).
3. New populations capable of self-perpetuation have been established within protected areas (USFWS, 2010).

Recovery Actions:

- Monitor existing populations (USFWS, 1994).
- Provide protection, through acquisition or conservation easements, for existing populations (USFWS, 1994).
- Develop management plan for the species where it occurs on Federal land (USFWS, 1994).
- Conduct research on aspects of the life history of the species and evaluate propagation techniques (USFWS, 1994).
- Conduct propagation and enhance existing populations or establish new ones (USFWS, 1994).
- Protection of currently known natural populations occurring on privately owned lands by establishing long-term conservation mechanisms such as Habitat Conservation Plans (HCP), conservation easements and conservation agreements with the landowners. (USFWS, 2019).
- Develop conservation and management plans with landowners that includes education on species description and needs and fire management. (USFWS, 2019)
- Establishment of new populations on protected lands within the Sierra Bermeja or other suitable habitats in southwestern Puerto Rico. (USFWS, 2019).
- Revise the recovery plans to include new information on the species and the development of measurable criteria for delisting the species (USFWS, 2010).
- Conduct comprehensive surveys of the species at Sierra Bermeja to determine relative abundance and distribution (USFWS, 2010).
- Conduct surveys at Cerro Las Mesas to determine if pelos del diablo is still present at this area (USFWS, 2010).

- Promote Conservation agreements with private landowners to protect and enhance existing populations (USFWS, 2010).
- Initiate propagation programs for these species to enhance existing populations in the Sierra Bermeja mountain range and establish new populations of pelos del diablo in protected areas in southwestern Puerto Rico (USFWS, 2010).
- Work closely with private landowners in the Sierra Bermeja mountain range and Peñones de Melones to protect individuals on private lands from existing agricultural practices and control exotic grasses (USFWS, 2010).
- Implement fire prevention practices in Sierra Bermeja, CNRWR and Peñones de Melones during dry season (USFWS, 2010).
- Continue to provide technical assistance to Service's Refuge Division for the development of the CCPs for CRNWR and LCNWR and to address current threats within the refuge (USFWS, 2010).
- Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of the species in the wild (USFWS, 2010).
- Determine the number of self-sustainable populations needed to delist the species (USFWS, 2010).
- Additional surveys should be conducted for the four species in Puerto Rico (USFWS, 2010).
- Continue protecting existing populations and their habitat (USFWS, 2010).
- Work closely with International Affairs to obtain information from pelos del diablo on the Island of Cuba (USFWS, 2010).

References

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016.

U.S. Fish and Wildlife Service. 1994. *Aristida portoricensis* Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 19 pp

USFWS 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office Boquerón, Puerto Rico

USFWS. 2019. *Aristida chaseae* (no common name), *Aristida portoricensis* (pelos del diablo), *Lyonia truncata* var. *proctorii* / (no common name), *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. USFWS, Southeast Region, Boqueron, Puerto Rico. 35 pp.

USFWS 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office Boquerón, Puerto Rico.

USFWS. 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological

Services Field Office Boquerón, Puerto Rico.

USFWS 1994. *Aristida portoricensis* Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 19 pp.

USFWS. 2019. *Aristida chaseae* (no common name), *Aristida portoricensis* (pelos del diablo), *Lyonia truncata* var. *proctorii* / (no common name), *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. USFWS, Southeast Region, Boqueron, Puerto Rico. 35 pp.

USFWS 2010. *Aristida chaseae* (no common name) *Aristida portoricensis* (pelos del diablo) *Lyonia truncata* var. *proctorii* / (no common name) *Vernonia proctorii* / (no common name) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office, Boquerón, Puerto Rico.

SPECIES ACCOUNT: *Brodiaea filifolia* (Thread-leaved brodiaea)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/13/1998; Pacific Southwest (R8) (USFWS, 2015)

Physical Description

A perennial herb with a flowering stem, 2-4 dm tall, and several shorter, narrow leaves arising from an underground bulb, a corm. Flowers (March-June) are violet to red-purple in color (NatureServe, 2015).

Taxonomy

A member of the Themidaceae family. When the Service listed *Brodiaea filifolia* (Service 1998, p. 54975), the species was considered to be in a large and broadly defined family, Liliaceae (Lily family). Salisbury (1866) recognized a group of several genera that includes taxa now named *Brodiaea*, as a family and distinct from *Allium* and other Liliaceae. He named the family Themidaceae (Salisbury 1866, pp. 84-87) (USFWS, 2009).

Historical Range

Endemic to southern California (NatureServe, 2015). The historical range of *Brodiaea filifolia* extends from the foothills of the San Gabriel Mountains at Glendora (Los Angeles County), east to Arrowhead Hot Springs in the western foothills of the San Bernardino Mountains (San Bernardino County), and south through eastern Orange and western Riverside Counties to Rancho Santa Fe in central coastal San Diego County, California (Figure 1 below; CNDDDB 2007) (USFWS, 2009).

Current Range

Presently known from Riverside, Los Angeles, San Bernardino, San Diego and Orange Counties (USFWS 2009).

Critical Habitat Designated

Yes; 2/8/2011.

Legal Description

On February 8, 2011, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Brodiaea filifolia* (Thread-leaved brodiaea) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes ten critical habitat units (CHUs), in California (76 FR 6848-6925).

Critical Habitat Designation

The critical habitat designation for *Brodiaea filifolia* includes ten CHUs (multiple sub-units) in Los Angeles, San Bernardino, Riverside, Orange, and San Diego Counties, California. This species critical habitat encompasses approximately 2,947 acres (ac) (1,193 hectares (ha)) (76 FR 6848-6925).

Unit 1: Los Angeles County: Unit 1 is located in Los Angeles County, and consists of two subunits totaling 206 ac (83 ha). This unit contains 13 ac (5 ha) of federally owned land and 192 ac (78 ha) of private land. Subunit 1a: Glendora: Subunit 1a consists of 67 ac (27 ha) of private land in the

City of Glendora, in the foothills of the San Gabriel Mountains in Los Angeles County. Lands within this subunit contain Cieneba-Exchequer-Sobranite soils, a type of silty loam, and consist primarily of northern mixed chaparral and coastal sage scrub habitat. Subunit 1a contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including sandy loam soils (PCE 1E) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports a rare or unique occurrence, representing one of two occurrences located in the foothills of the San Gabriel Mountains which are part of the Transverse Ranges where the species was historically found, and is also significant because it is the northernmost occurrence known; and (3) supports a stable, persistent occurrence of approximately 2,000 plants. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants. The site is protected from development and is owned by the Glendora Community Conservancy (GCC). The GCC has expressed interest in creating a management plan for their land; however, a comprehensive management plan that would specifically address the control of nonnative plants has not been completed at this time. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 1b: San Dimas: Subunit 1b consists of 13 ac (5 ha) of Federal land (Angeles National Forest) and 125 ac (51 ha) of private land near the City of San Dimas in the foothills of the San Gabriel Mountains in Los Angeles County. Lands within this subunit contain Cieneba-Exchequer-Sobranite soils, a type of silty loam, and consist primarily of northern mixed chaparral and coastal sage scrub habitat. Subunit 1b contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including sandy loam soils (PCE 1E) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports a rare or unique occurrence, representing one of two occurrences located in the foothills of the San Gabriel Mountains which are part of the Transverse Ranges where the species was historically found, and represents the only likely genetic connection to plants in the Glendora subunit; and (3) supports two significant populations totaling about 6,000 individuals of *B. filifolia*, as documented in 1990 (CNDDDB 2009, p. 37). Several proposals for development of this area have been reviewed by the City of Glendora (D. Walter, Senior Planner City of Glendora pers. comm. to G. Wallace, Service 2005). Additionally, illegal grading has occurred on the northern portion of this subunit (grading was halted by the City of Glendora). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from urban development on private lands, including minimizing disturbance to the surface and subsurface structure, and to maintain pollinator habitat. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 2: San Bernardino County— Arrowhead Hot Springs: Unit 2 is located in San Bernardino County, California, and consists of 61 ac (25 ha) of private land at the southwestern base of the San Bernardino Mountains. This unit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this unit contain Cieneba-rock outcrop complex and Ramona family-Typic Xerothents soils altered by hydrothermal activity, some of which are considered alluvial, and consist primarily of coastal sage scrub habitat. Unit 2 contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for

B. filifolia, including soils altered by hydrothermal activity (PCE 1B) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports a rare or unique occurrence, representing the only occurrence of this plant in the foothills of the San Bernardino Mountains part of the Transverse Ranges where the species was historically found, and representing the type locality for *B. filifolia* (Niehaus 1971, p. 57; CNDDDB 2009, p. 7); and (3) supports a stable, persistent occurrence. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 3: Central Orange County—Aliso Canyon: Unit 3 is located in central Orange County, California, and consists of 11 ac (4 ha) of private land in the City of Laguna Niguel, southwestern Orange County. These totals do not include 102 ac (42 ha) of land in Unit 3 that we are exercising our delegated discretion to exclude from this revised designation under section 4(b)(2) of the Act (see the Exclusions under Section 4(b)(2) of the Act section of this rule). This unit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this unit contain clay loam or other types of loam and consist of annual and needlegrass grassland. Unit 3 contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports an occurrence of at least 5,000 individuals of *B. filifolia*, as documented in 2001 (CNDDDB 2009, p. 51). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from fuel management activities (annual mowing) and pipeline work. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 4: Southern Orange County: Unit 4 is located in southern Orange County, California, and consists of 3 subunits totaling 732 ac (297 ha) of private land. These totals do not include portions of Subunit 4b (192 ac (78 ha)) that we are exercising our delegated discretion to exclude from this revised designation under section 4(b)(2) of the Act (see the Exclusions under Section 4(b)(2) of the Act section of this rule). Subunits 4a, 4d, 4e, 4f, 4h, and 4i as proposed in the December 8, 2004, rule (69 FR 71283) did not meet the definition of critical habitat and were not proposed for revised designation. **Subunit 4b: Wilderness Park:** Subunit 4b consists of 12 ac (5 ha) of private land in the City of San Juan Capistrano and the Audubon California Starr Ranch Sanctuary, in the southwestern region of the Santa Ana Mountains, southern Orange County. Lands within this subunit contain clay loam, sandy loam, or rocky outcrop, and consist primarily of grassland and sagebrush-buckwheat scrub habitat. Subunit 4b contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including clay soils and loamy soils underlain by a clay subsoil (PCE 1A), and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence. This subunit is located in the foothills of the Santa Ana Mountains and represents the highest elevation and northernmost occurrence in Orange County. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or

protection to address threats from nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 4c: Can~ada Gobernadora/Chiquita Ridgeline: Subunit 4c consists of 133 ac (54 ha) of private land in and around Can~ada Gobernadora on Rancho Mission Viejo in southern Orange County. Lands within this subunit contain clay, clay loam, or sandy loam and consist primarily of dry-land agriculture and sagebrush-buckwheat scrub habitat. Subunit 4c contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including clay soils and loamy soils underlain by a clay subsoil (PCE 1A), and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 4g: Cristianitos Canyon: Subunit 4g consists of 587 ac (238 ha) of privately owned land in Cristianitos Canyon on Rancho Mission Viejo in southern Orange County. Lands within this subunit are underlain by clay and sandy loam soils and consist primarily of annual grassland and needlegrass grassland. Subunit 4g contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including clay soils and loamy soils underlain by a clay subsoil (PCE 1A), and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports an occurrence in rare and unique habitat, representing one of the few places where this species occurs in needlegrass grassland in Orange County; and (3) supports an occurrence of at least 6,505 individuals of *B. filifolia*, as documented in 2003 (Dudek & Associates, Inc. 2006, Chapter 3 pp. 73– 74, 83; Service 2007, pp. 149–150). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 5: Northern San Diego County: Unit 5 is located in northern San Diego County, and consists of one subunit totaling 274 ac (111 ha). This unit contains 266 ac (108 ha) of Federal Government land and 8 ac (3 ha) of private land. This unit is located entirely within the boundary of the CNF.

Subunit 5a as proposed in the December 8, 2004, rule (69 FR 71283) did not meet the definition of critical habitat and was not proposed for revised designation.

Subunit 5b: Devil Canyon: Subunit 5b consists of 266 ac (108 ha) of Federal land (CNF) and 8 ac (3 ha) of private land in northern San Diego County. Hybrids between *Brodiaea filifolia* and *B. orcuttii* have been reported from the Devil Canyon site, however, we believe *B. filifolia* occurs in sufficient numbers in this area to meet the criteria for critical habitat designation (see the Special Management Considerations or Protection section of this rule for a discussion of *Brodiaea* hybridization). Lands within this subunit contain Cieneba Very Rocky Coarse Sandy Loam, Fallbrook Sandy Loam, and Cieneba Coarse Sandy Loam soils and consist primarily of chaparral and oak woodland vegetation. Subunit 5b contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including sandy loam soils (PCE 1E) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports an occurrence in rare and unique

habitat, representing one of the few places where this species occurs in a drainage in oak woodland habitat and occurring in unusual seeps and drainages on low granitic outcrops; and (3) supports a stable, persistent occurrence. The CNF does not currently have a management plan specific to *B. filifolia*. The 2005 critical habitat rule for *B. filifolia* and the 2009 proposed revised critical habitat rule erroneously stated that grazing occurs in this area; this area is in fact not subjected to cattle grazing (Winter 2004, pers. comm.). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 6: Oceanside, San Diego County: Unit 6 is located in Oceanside, San Diego County, California, and consists of five subunits totaling 230 ac (93 ha) of private land. Subunit 6a: Alta Creek: Subunit 6a consists of 72 ac (29 ha) of private land in the City of Oceanside, in northern coastal San Diego County. This subunit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this subunit contain fine sandy loam, loam, or loamy fine sand and consist primarily of coastal sage scrub habitat. Subunit 6a contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence of at least 1,500 individuals of *B. filifolia* (Affinis 2005, pp. 1–3; AMEC 2005 pp. 3–18). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations. Subunit 6b: Mesa Drive: Subunit 6b consists of 17 ac (7 ha) of private land in the City of Oceanside, in northern coastal San Diego County. Lands within this subunit contain loamy fine sands and consist primarily of grassland habitat. Subunit 6b contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence of at least 1,500 individuals of *B. filifolia* (Roberts 2005a, pp.1–2). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development and habitat disturbance on local government lands (Roberts 2005, pp. 1–3). Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations. Subunit 6c: Mission View/Sierra Ridge: Subunit 6c consists of 12 ac (5 ha) of private land in the City of Oceanside, in northern coastal San Diego County. This subunit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this subunit contain fine loamy sands and consist primarily of coastal sage scrub habitat. Subunit 6c contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence of at least 1,300

individuals of *B. filifolia* (Roberts 2005b, p. 1). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 6d: Taylor/Darwin: Subunit 6d consists of 35 ac (14 ha) of private land in the City of Oceanside, in northern coastal San Diego County. Lands within this subunit contain clay soil and fine loamy sands and consist primarily of annual and needlegrass grassland. Subunit 6d contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports an occurrence of at least 6,200 individuals of *B. filifolia*, as documented in 2005 (CNDDDB 2009, p. 38). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 6e: Arbor Creek/Colucci: Subunit 6e consists of 94 ac (38 ha) of private land in the City of Oceanside, in northern coastal San Diego County. This subunit was not included in the 2005 final critical habitat designation but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this subunit contain clay soil and fine loamy sands and consist primarily of annual and needlegrass grassland. Subunit 6e contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence; and (3) consists primarily of annual and needlegrass grassland and occurs in the largest continuous block of grassland habitat remaining in the City of Oceanside. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants and urban development. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 7: Carlsbad, San Diego County: Unit 7 is located in Carlsbad, San Diego County, California, and consists of three subunits totaling 105 ac (43 ha). This unit contains 1 ac (<1 ha) of State land and 104 ac (43 ha) of private land. These totals do not include Subunit 7d (98 ac (40 ha)) and portions of Subunit 7a (13 ac (5 ha)) and Subunit 7c (45 ac (18 ha)) that we are exercising our delegated discretion to exclude from this revised designation under section 4(b)(2) of the Act (see the Exclusions under Section 4(b)(2) of the Act section of this rule), or 2 ac (<1 ha) that were proposed as revised critical habitat but are not included in this final revised critical habitat designation because they do not support suitable habitat for the species.

Subunit 7a: Letterbox Canyon: Subunit 7a consists of 1 ac (<1 ha) of State land and 41 ac (17 ha) of private land in the City of Carlsbad, in northern coastal San Diego County, California. Lands within this subunit contain heavy clay soils and consist primarily of annual grassland. Subunit 7a contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports an occurrence of at least 39,500 individuals of *B.*

filifolia, as documented in 2005 (CNDDDB 2009, p. 15). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 7b: Rancho Carrillo: Subunit 7b consists of 37 ac (15 ha) of private land in the City of Carlsbad, in northern coastal San Diego County, California. This subunit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this subunit contain clay or sandy loam soils and consist primarily of annual grasslands and coastal sage scrub habitat. Subunit 7b contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports an occurrence of at least 797,000 individuals of *B. filifolia*, as documented in 2005 (this estimate was of vegetative plants and not flowering plants) (Scheidt and Allen 2005, p. 1). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development and nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 7c: Calavera Hills Village H: Subunit 7c consists of 26 ac (11 ha) of private land in the City of Carlsbad, in northern coastal San Diego County. Lands within this subunit contain clay soil and consist primarily of annual and needlegrass grassland. Subunit 7c contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence of at least 2,243 plants, as documented in 2008 (McConnell 2008, p. 9). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 8: San Marcos, San Diego County: Unit 8 is located in San Marcos, northern San Diego County, California, and consists of three subunits totaling 108 ac (44 ha) of private land. Subunits 8a, 8c, and 8e as proposed in the December 8, 2004, rule (69 FR 71283) did not meet the definition of critical habitat and were not proposed for revised designation.

Subunit 8b: Rancho Santalina/Loma Alta: Subunit 8b consists of 47 ac (19 ha) of private land in the City of San Marcos, northern San Diego County, California. This subunit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this subunit contain clay, loam, or loamy fine sand soils and consist primarily of annual and needlegrass grassland. Subunit 8b contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports an occurrence of at least 5,552 individuals of *B. filifolia*, as documented in 2000, and approximately 12,000 *B. filifolia* corms were transplanted to the area in 2004 (CNDDDB 2009, p. 10). The physical and biological features essential to the

conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development, unauthorized recreational activities, and nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations. Subunit 8d: Upham: Subunit 8d consists of 54 ac (22 ha) of private land in the City of San Marcos, northern San Diego County. Hybrids between *Brodiaea filifolia* and *B. orcuttii* have been reported from the Upham site (Chester et al. 2007, p. 188), however, based on the best scientific information available to us at this time, we believe *B. filifolia* occurs in sufficient numbers in this area to meet the criteria for critical habitat designation (see the Special Management Considerations or Protection section of this rule for a discussion of *Brodiaea* hybridization). Lands within this subunit contain clay soils and consist primarily of annual and needlegrass grassland and vernal pool habitat. Subunit 8d contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports a rare or unique occurrence, representing one of three occurrences that are associated with vernal pool habitat; and (3) supports an occurrence of at least 342,000 individuals of *B. filifolia*, as documented in 1993 (CNDDDB 2009, p. 9). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development, unauthorized recreational activities, and nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations. Subunit 8f: Oleander/San Marcos Elementary: Subunit 8f consists of 7 ac (3 ha) of land owned by the San Marcos Unified School District near the City of San Marcos, in northern San Diego County. This subunit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this subunit contain clay, loam, or loamy fine sand soils and consist primarily of annual grassland. Unit 8f contains the physical and biological features essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports an occurrence of at least 3,211 individuals of *B. filifolia*, as documented in 2005 (Dudek and Associates, Inc. 2007, p.9). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 11: Western Riverside County: Unit 11 is located in western Riverside County, California, and consists of 6 subunits totaling 1,113 ac (450 ha). This unit contains 53 ac (21 ha) of Federal land, 366 ac (148 ha) of State land, 33 ac (13 ha) of local government land, and 661 ac (267 ha) of private land. These totals do not include Subunits 11g (117 ac (47 ha)), 11h (44 ac (18 ha)) and portions of Subunit 11f (221 ac (89 ha)) that we are exercising our delegated discretion to exclude from this revised designation under section 4(b)(2) of the Act (see the Exclusions under Section 4(b)(2) of the Act section of this rule). Subunit 11a: San Jacinto Wildlife Area: Subunit 11a consists of 366 ac (148 ha) of State land (California Department of Fish and Game (CDFG)), 17 ac (7 ha) of local government land, and 18 ac (7 ha) of private land at the San Jacinto Wildlife Area,

in western Riverside County. Lands within this subunit contain Willows silty clay, Waukena loam and Waukena fine sandy loam, Traver fine sandy loam and Traver loamy fine sand, and Hanford coarse sandy loam soils and consist primarily of annual grassland, alkali scrub habitat, and alkali playa habitat. Subunit 11a contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including silty loam soils underlain by a clay subsoil or caliche that are generally poorly drained and moderately to strongly alkaline (PCE 1C) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports a rare or unique occurrence, representing one of four occurrences associated with alkali playa habitat; and (3) supports a stable, persistent occurrence. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants and construction of new roads or improvements to existing roadways (Service 2004b, pp. 137–189). Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 11b: San Jacinto Avenue/ Dawson Road: Subunit 11b consists of 117 ac (47 ha) of private land near San Jacinto Avenue and Dawson Road, in western Riverside County. Lands within this subunit contain Willows silty clay and Domino silt loam soils and consist primarily of annual grassland, alkali scrub habitat, and alkali playa habitat. Subunit 11b contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including silty loam soils underlain by a clay subsoil or caliche that are generally poorly drained and moderately to strongly alkaline (PCE 1C) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a rare or unique occurrence, representing one of four occurrences that are associated with alkali playa habitat. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from discing, grazing, manure dumping, and nonnative invasive plants (CNDDDB 2009, p. 60). Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 11c: Case Road: Subunit 11c consists of 11 ac (4 ha) of local government land and 169 ac (68 ha) of private land near the City of Perris, in western Riverside County. Lands within this subunit contain Willows silty clay and Domino silt loam soils and consist primarily of agricultural land, floodplain habitat, alkali scrub habitat, and alkali playa habitat. Subunit 11c contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including silty loam soils underlain by a clay subsoil or caliche that are generally poorly drained and moderately to strongly alkaline (PCE 1C) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports a rare or unique occurrence, representing one of four occurrences that are associated with alkali playa habitat; and (3) supports an occurrence of at least 4,555 individuals of *B. filifolia*, as documented in 2000 (Glenn Lukos Associates, Inc. 2000a, Map of San Jacinto River Stage 3 Project Impacts Version 2 Alignment; Glenn Lukos Associates, Inc. 2000b, pp. 17–18; CNDDDB 2009, p. 2). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from OHV activity, encroaching urban development, manure dumping, and nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 11d: Railroad Canyon: Subunit 11d consists of 53 ac (21 ha) of Federal land owned by the Bureau of Land Management, 1 ac (<1 ha) of local government land, and 204 ac (83 ha) of private land

north of Kabian County Park and southwest of the City of Perris, in western Riverside County. Lands within this subunit contain Lodo rocky loam, Garretson gravelly very fine sandy loam and Garretson very fine sandy loam, Escondido fine sandy loam, and Grangeville fine sandy loam soils and consist primarily of annual grassland. Subunit 11d contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including silty loam soils underlain by a clay subsoil or caliche that are generally poorly drained and moderately to strongly alkaline (PCE 1C) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports an occurrence of at least 3,205 individuals of *B. filifolia*, as documented in 2000 (Glenn Lukos Associates 2000a, pp. 13, 24; CNDDDB 2009, p. 23). The occurrence in Railroad Canyon is at risk from the San Jacinto River Flood Control Project. That project includes channelization of the river, which may result in changes in floodplain process essential to the species persistence in this subunit (Service 2004b, p. 382). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development, river channelization for flood control, and nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 11e: Upper Salt Creek (Stowe Pool): Subunit 11e consists of 145 ac (59 ha) of private land in the Upper Salt Creek drainage west of Hemet, in western Riverside County. Lands within this subunit contain Willows silty clay, Chino silt loam, Honcut loam, and Wyman loam and consist primarily of annual grassland, alkali scrub habitat, and alkali playa habitat. Subunit 11e contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including silty loam soils underlain by a clay subsoil or caliche that are generally poorly drained and moderately to strongly alkaline (PCE 1C), and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a rare or unique occurrence, representing one of three occurrences that are associated with vernal pool habitat. This subunit is crossed by roadways that, if altered (widened or realigned), could change the topography and thereby negatively affect the hydrologic integrity of the pool complexes and favor the growth of nonnative invasive plant species (CNDDDB 2009, p. 24; Service 2004b, p. 382). The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from nonnative invasive plants (such as *Hordeum marinum* subsp. *gussoneanum*) and transportation projects. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Subunit 11f: Santa Rosa Plateau—Mesa de Colorado: Subunit 11f consists of 5 ac (2 ha) of local government land and 8 ac (3 ha) of private land in southwestern Riverside County. Lands within this subunit contain Murrieta stony clay loam, and Las Posas rocky loam and Las Posas loam soils and consist primarily of annual and needlegrass grassland and vernal pool habitat. Subunit 11f contains the physical and biological features essential to the conservation of *Brodiaea filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including clay loam soil series underlain by heavy clay loams or clays derived from olivine basalt lava flows that generally occur on mesas and gentle to moderate slopes (PCE 1D) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); (2) supports a rare or unique occurrence, representing one of three occurrences that are associated with vernal pool habitat; and (3) supports an occurrence of at least 31,725 individuals of *B. filifolia*, as documented in 1990 (CNDDDB 2009, p. 5). The physical and biological features essential to the conservation of the species in this subunit may require

special management considerations or protection to address threats from the indirect effects associated with urban development and nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

Unit 12: Central San Diego County—Artesian Trails Unit 12 is located in central San Diego County, California, and consists of 105 ac (43 ha). This unit contains 7 ac (3 ha) of local government land and 98 ac (40 ha) of private land. These totals do not include 4 ac (2 ha) of land in Unit 12 that we are exercising our delegated discretion to exclude from this revised designation under section 4(b)(2) of the Act (see the Exclusions under Section 4(b)(2) of the Act section of this rule). This unit was not included in the 2005 final critical habitat designation, but is included in this rule based on new information related to the distribution of *Brodiaea filifolia*. Lands within this subunit contain fine loamy sands and consist primarily of coastal sage scrub habitat and annual grassland. Unit 12 contains physical and biological features that are essential to the conservation of *B. filifolia* because it: (1) Contains the PCEs for *B. filifolia*, including loamy soils underlain by a clay subsoil (PCE 1A) and areas with a natural, generally intact surface and subsurface soil structure that support *B. filifolia* and pollinator habitat (PCE 2); and (2) supports a stable, persistent occurrence. The physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from the indirect effects associated with urban development and nonnative invasive plants. Please see the Special Management Considerations or Protection section of this rule for a discussion of the threats to *B. filifolia* habitat and potential management considerations.

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 *Brodiaea filifolia* critical habitat consists of two components (76 FR 6848-6925):

(i) PCE 1—Appropriate soil series at a range of elevations and in a variety of plant communities, specifically: (A) Clay soil series of various origins (such as Alo, Altamont, Auld, or Diablo), clay lenses found as unmapped inclusions in other soils series, or loamy soils series underlain by a clay subsoil (such as Fallbrook, Huerhuero, or Las Flores) occurring between the elevations of 100 and 2,500 ft (30 and 762 m). (B) Soils (such as Cienega-rock outcrop complex and Ramona familyTypic Xerothents soils) altered by hydrothermal activity occurring between the elevations of 1,000 and 2,500 ft (305 and 762 m). (C) Silty loam soil series underlain by a clay subsoil or caliche that are generally poorly drained, moderately to strongly alkaline, granitic in origin (such as Domino, Grangeville, Traver, Waukena, or Willows) occurring between the elevations of 600 and 1,800 ft (183 and 549 m). (D) Clay loam soil series (such as Murrieta) underlain by heavy clay loams or clays derived from olivine basalt lava flows occurring between the elevations of 1,700 and 2,500 ft (518 and 762 m). (E) Sandy loam soils derived from basalt and granodiorite parent materials; deposits of gravel, cobble, and boulders; or hydrologically fractured, weathered granite in intermittent streams and seeps occurring between 1,800 and 2,500 ft (549 and 762 m).

(ii) PCE 2—Areas with a natural, generally intact surface and subsurface soil structure, not permanently altered by anthropogenic land use activities (such as deep, repetitive discing, or grading), extending out up to 820 ft (250 m) from mapped occurrences of *Brodiaea filifolia* to provide for space for individual population growth, and space for pollinators.

Special Management Considerations or Protections

When designating critical habitat within the geographical area occupied by the species at the time of listing, we assess whether the physical or biological features essential to the conservation of the species may require special management considerations or protection. In all units/subunits, special management considerations or protection of the essential features may be required to provide for the growth, reproduction, and sustained function of the habitat on which *Brodiaea filifolia* depends. The lands designated as revised critical habitat represent our best assessment of the habitat that meets the definition of critical habitat for *Brodiaea filifolia* at this time. The essential physical or biological features within the areas designated as revised critical habitat may require some level of management to address current and future threats to *B. filifolia*, including the direct and indirect effects of habitat loss and degradation from urban development; the introduction of nonnative invasive plant species; recreational activities; discing and mowing for agricultural practices or fuel modification for fire management; dumping of manure and sewage sludge; and hybridization with other species of *Brodiaea*. Loss and degradation of habitat from development was cited in the final listing rule as a primary cause for the decline of *Brodiaea filifolia*. Most of the populations of this species are located in San Diego, Orange, and Riverside counties. These counties have had (and continue to have) increasing human populations and attendant housing pressure. Natural areas in these counties are frequently near or bounded by urbanized areas. Urban development removes the plant community components and associated clay soils identified in the PCEs, which eliminates or fragments the populations of *B. filifolia*. Grading, discing, and scraping areas in the preparation of areas for urbanization also directly alters the soil surface as well as subsurface soil layers to the degree that they will no longer support plant community types and pollinators associated with *B. filifolia* (PCE 2). Conservation and management of *B. filifolia* habitat and adjacent pollinator habitat is needed to address the threat of development. Nonnative invasive plant species may alter the vegetation composition or physical structure identified in the PCEs to an extent that the area does not support *Brodiaea filifolia* or the plant community that it inhabits. Additionally, invasive species may compete with *B. filifolia* for space and resources by depleting water that would otherwise be available to *B. filifolia*. Management activities including (but not limited to) nonnative plant removal and control are needed to reduce this threat. Unauthorized recreational activities may impact the vegetation composition and soil structure that supports *Brodiaea filifolia* to an extent that the area will no longer have intact soil surfaces or the plant communities identified in the PCEs. Off-highway vehicle (OHV) activity is an example of this type of activity. Management activities such as (but not limited to) fencing or other barriers to unauthorized access, signage, and monitoring are needed to address this threat. Some methods of mowing or discing for agricultural purposes or fuel modification for fire management may preclude the full and natural development of *Brodiaea filifolia* by adversely affecting the PCEs. Mowing may preclude the successful reproduction of the plant, or alter the associated vegetation needed for pollinator activity (PCE 2). Dumping of sewage sludge can cover plants as well as the soils they need. Additionally, this practice can alter the chemistry of the substrate and lead to alterations in the vegetation supported at the site (PCE 1). Management activities such as (but not limited to) fencing, signage, and education of landowners and land managers about the detrimental effects that mowing, discing, and dumping sewage have on *B. filifolia* and its habitat are needed to address this threat. Manure dumping on private property along the San Jacinto River area is impacting habitat within the Western Riverside County MSHCP plan area. These impacts are occurring despite identification of these areas as important for the survival and recovery of *Brodiaea filifolia* in the Western Riverside County MSHCP. Manure dumping is not a covered

activity under the Western Riverside County MSHCP and was not discussed as an impact to *B. filifolia* in the Biological Opinion on the Western Riverside County MSHCP (Service 2004b, pp. 378–386). As outlined in the Western Riverside County MSHCP, we have been working with permittees to implement additional ordinances that will help to control activities (such as manure dumping) that may impact the implementation of the Western Riverside County MSHCP conservation objectives. To date, the City of Hemet is the only Western Riverside County MSHCP permittee that has addressed the negative impacts that manure dumping has on species such as *B. filifolia* and *Navarretia fossalis* and their habitats through the enactment of Ordinance 1666 (i.e., the ordinance that prevents manure dumping activities and educates its citizens). We will continue to work with Riverside County and permittees of the Western Riverside County MSHCP to address activities that may impact the species within the Western Riverside County MSHCP plan area. The Service is aware of occurrences of some hybrids within the range of *Brodiaea filifolia* in Subunit 5b (Devil Canyon) in northwestern San Diego County (Chester et al. 2007, p. 193). The presumed parent taxa of these hybrids are considered to be *B. filifolia* and *B. orcuttii* because of the apparent morphological intermediacy of the individuals and proximity of their ranges. This is supported by the close relationship of the two species noted above. Although there are some hybrids of *B. filifolia* and *B. orcuttii* in this subunit, it is likely that a minimum of 850 plants are pure *B. filifolia* (Service 2009b, p. 15) (we consider occurrences that have between 850 and 3,000 flowering stems observed in multiple years to be stable and persistent because we expect these occurrences to have a sufficient amount of corms to sustain the occurrence for a number of years if the habitat remains unaltered (see Criteria Used section below)). Plants of hybrid origin have also been reported in Subunit 8d (Upham) in the City of San Marcos (Chester et al. 2007, p. 191). Chester et al. (2007) only found a few hybrid specimens at this location, therefore it is likely that a minimum of 850 plants are pure *B. filifolia*. Hybridization could result in the loss of portions of *B. filifolia* occurrences if other *Brodiaea* species are transplanted adjacent to existing *B. filifolia* occurrences, or if existing *B. filifolia* occurrences are transplanted adjacent to other *Brodiaea* species and the two species are able to hybridize. Informing biological resource managers of the existence of this threat will help to keep human-mediated hybridization from occurring. In summary, we find that the areas we are designating as revised critical habitat contain the physical or biological features essential to the conservation of *Brodiaea filifolia*, and that these features may require special management considerations or protection. Special management considerations or protection may be required to eliminate, or reduce to negligible level, the threats affecting each unit/subunit and to preserve and maintain the essential features that the revised critical habitat units/subunits provide to *B. filifolia*. Additional discussions of threats facing individual sites are provided in the individual unit/subunit descriptions. The designation of critical habitat does not imply that lands outside of critical habitat may not play an important role in the conservation of *Brodiaea filifolia*. In the future, and with changed circumstances, these lands may become essential to the conservation of *B. filifolia*. Activities with a Federal nexus that may affect areas outside of revised critical habitat, such as development, agricultural activities, and road construction, are still subject to review under section 7 of the Act if they may affect *B. filifolia* because Federal agencies must consider both effects to the plant and effects to critical habitat independently. The prohibitions of section 9 of the Act applicable to *B. filifolia* under 50 CFR 17.71 (e.g., the prohibition against reducing to possession or maliciously damaging or destroying listed plants on Federal lands) also continue to apply both inside and outside of designated critical habitat.

Life History

Food/Nutrient Resources**Reproductive Strategy**

Adult: Asexual: vegetative; sexual: cross-pollination (NatureServe, 2015)

Breeding Season

Adult: March - June (USFWS, 2009)

Key Resources Needed for Breeding

Adult: Bee pollinators (USFWS, 2009). Multiple potential pollinators including multiple Coleoptera, Hymenoptera species (USFWS, 2023)

Other Reproductive Information

Adult: Pollination studies were initiated at MCBCP and by CNLM since the last 5-year review. Between 2018 and 2020, the CNLM implemented a pollination study at several of the preserves they manage in San Diego County (Prentice-Dekker 2019, pp. 5–6, 12–14; Prentice-Dekker 2020, pp. 5, 7–10). The study assessed pollinator abundance diversity, visitation rates, and measured seed pod and seed production (Prentice-Dekker 2019, pp. 12–14; Prentice-Dekker 2020, pp. 7–10). Successful pollination, defined as at least one seed pod and seed produced, was observed at 16 (18 percent) of the 90 plants measured in 2020 (Prentice-Dekker 2020, p. 9). At MCBCP, several native and nonnative potential pollinators were observed (Kenney 2021, in litt;) (Appendix A); observations from both studies contribute to our understanding of potential *Brodiaea filifolia* pollinators. Additional research is needed to characterize the range of seed set and whether certain populations may have reduced sexual reproduction due to pollinator limitation or reduced genetic diversity (USFWS, 2023).

Reproduction Narrative

Adult: *Brodiaea filifolia*'s main means of reproduction is vegetative; it produces small cormlets. When reproducing sexually, this species is an obligate out-crosser, in other words it cannot produce seed when pollinated by flowers on the same plant or flowers from other plants that have the same alleles (USFWS 2005) (NatureServe, 2015). The California Native Plant Society (CNPS) reported that the flowering period extends from March to June (CNPS 2001, p. 99). Bell and Rey (1991) report that native bees observed pollinating *Brodiaea filifolia* on the Santa Rosa Plateau in Riverside County included *Bombus californicus* (Apidae, Hymenoptera), *Hoplitis* sp. (Megachilidae, Hymenoptera), *Osmia* sp. (Megachilidae, Hymenoptera), and an unidentified Anthophorid (digger-bee) (Bell and Rey 1991, p. 3) (USFWS, 2009).

Habitat Type

Adult: Terrestrial, wetland (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Grassland, alkali playa, vernal pool (USFWS, 2009)

Dependencies on Specific Environmental Elements

Adult: Mesic conditions (USFWS, 2009)

Geographic or Habitat Restraints or Barriers

Adult: 100 - 2,500 ft. elevation (USFWS, 2009)

Environmental Specificity

Adult: Very narrow to narrow (NatureServe, 2015)

Habitat Narrative

Adult: Grasslands, often in association with vernal pools and in floodplains. Grows in heavy clay soil (Munz, 1959). The environmental specificity is very narrow to narrow; it requires clay soils in herbaceous communities (USFWS 2005) (NatureServe, 2015). This species is usually found in herbaceous plant communities that occur in open areas on clay soils, soils with a clay subsurface, or clay lenses within loamy, silty loam, loamy sand, silty deposits with cobbles, or alkaline soils. They may range in elevation from 100 feet (30 meters) to 2,500 feet (765 meters), depending on soil series. This species is usually found in herbaceous plant communities such as valley needlegrass grassland, valley sacaton grassland, nonnative grassland, alkali playa, southern interior basalt vernal pools, San Diego mesa hardpan vernal pools, and San Diego mesa claypan vernal pools (Holland 1986, pp. 34-37, 41, 44) (USFWS, 2009).

Dispersal/Migration**Dispersal**

Adult: Low (USFWS, 2009)

Dispersal/Migration Narrative

Adult: The seeds are dispersed as wind rattles the capsules and releases the seeds (Smith 1997, p. 29). Dispersal of seeds from an individual is likely localized, leading to patches of plants with the same self-incompatible alleles (USFWS, 2009).

Population Information and Trends**Population Trends:**

Not available

Species Trends:

3 occurrences extirpated since listing (USFWS, 2009)

Number of Populations:

148 extant/presumed extant (USFWS, 2023)

Population Size:

Unknown (USFWS, 2009)

Population Narrative:

Sixty-eight discontinuous occurrences are distributed across southern California. No accurate estimate of the overall abundance of *Brodiaea filifolia* is available at this time. Only three occurrences are considered to be extirpated since listing (USFWS, 2009). This 2023 review of new information finds that there is a substantial increase in the number of occurrences: a total of 148 occurrences are extant or presumed extant, and 18 are possibly extirpated or extirpated (Figure 1; Table 1). Although new occurrences of the plant have been found since listing, none of the new documented occurrences are outside of the original range identified in the final listing

rule (Service 1998, p. 54977). The current distribution is discussed by county below and maps by county can be found in Appendix B (USFWS, 2023).

Threats and Stressors

Stressor: Urbanization (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Development may directly impact *B. filifolia* plants through removal, reduction of suitable habitat, and increased isolation between occurrences. At least 151 individuals in three locations within the San Dimas/Gordon Highlands occurrence were destroyed (LDC 2006, pp. 1, 47-48) and the remaining individuals are likely to be impacted by future development (M. Meyer, California Department of Fish and Game, in litt. 2005, p. 1). A proposed channelization associated with the San Jacinto River Flood Control Project may result in the translocation of the Railroad Canyon occurrence (Dudek 2003, p. 438; Service 2004b, pp. 384-385). Of the 20 occurrences in San Diego County, 12 of them have been impacted by development. At the Loma Alta occurrence in the City of San Marcos, unforeseen impacts to *Brodiaea filifolia* occurred when approximately 4,000 plants, that were to be conserved, were buried by a manufactured slope, leaving only 13 plants (Roberts, in litt. 2001, pp. 1-5; CDFG and Service 2002, p. 2; Roberts, in litt. 2004a, p. 1). Occurrences of *Brodiaea filifolia* in the cities of Oceanside and San Marcos are not yet addressed under the MHCP because these cities have not completed their respective subarea plans; *B. filifolia* occurrences in these cities are not yet assured of conservation or management and remain threatened by development (USFWS, 2009).

Stressor: Alteration of hydrological conditions (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Alteration of site hydrology as a result of urbanization potentially threatens *Brodiaea filifolia*. *Brodiaea filifolia* requires moist clay soils to facilitate seedling and cormlet disposition to an appropriate soil depth, and corm persistence through seedling and adult phases of flowering and fruit set. Development projects upslope and adjacent to *B. filifolia* occurrences may dewater the site, interfering with these processes. Conversely, water runoff from nearby developments may inundate *B. filifolia* occurrences with excessive amounts of water, depositing silt, and drowning plants. Alteration of hydrological conditions and channelization currently pose a threat to five *B. filifolia* occurrences in Riverside County (USFWS, 2009).

Stressor: Discing and mowing (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: There are at least 12 occurrences of *Brodiaea filifolia* threatened by discing or mowing, but additional occurrences may also be subject to this because site-specific threats are not fully known for all of the extant occurrences. Discing may cut up and/or bury the entire plant, including the underground corms. Either of these actions suppresses growth and reduces reproductive output. Systematic discing up to four times a year has been reported on some sites along the San Jacinto River (Roberts, in litt. 2003, p. 1). In 2008, Service staff noted habitat

degradation and recent discing within the Case Road occurrence (A. Braswell, U.S. Fish and Wildlife Service, pers. obs. 2008, p. 3). Illegal discing was also reported at the Oleander/San Marcos Elementary occurrence in the City of San Marcos, San Diego County, impacting an estimated 3,802 individual plants (Dudek 2005, p. 19). Mowing may reduce the production and dispersal of seeds, alter the associated vegetation needed for pollinator activity, or reduce the number and vigor of plants present by cutting off the leaves (Service 2005a, p. 73839). Mowing has occurred at two sites in the City of Oceanside (USFWS, 2009).

Stressor: Nonnative plants (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Invasive, nonnative plants may compete for space and resources, and alter habitat in an area to the extent that it no longer supports *B. filifolia*. Since listing, Dudek (2006) identified the invasion of nonnative plants as likely “the main stressor” to seven occurrences within southern Orange County (Dudek 2006, p. E-440). Some *Brodiaea filifolia* preserves within the City of Carlsbad in San Diego County have required significant effort to control nonnative plants (J. Vinje, Center for Natural Lands Management, pers. comm. 2007, pp. 1-3). Approximately 25 percent (17 of 68) of *Brodiaea filifolia* occurrences are currently reported to be threatened by nonnative plants (USFWS, 2009).

Stressor: Grazing (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Dudek (2006, p. E-440) identified cattle-related impacts, including trampling and crushing of soils, and browsing of vegetation and flower stalks during the growing season as an “environmental stressor” to seven occurrences of *B. filifolia* in southern Orange County (Dudek 2006, p. E-440). Grazing may be a threat to about 18 percent (12 of 68) of *Brodiaea filifolia* occurrences, primarily by trampling of plants, but rangewide it is not likely to pose a threat to the continued existence of *B. filifolia* (USFWS, 2009).

Stressor: Off-highway vehicles (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: At least 18 percent (12 of 68) of *Brodiaea filifolia* occurrences are noted as threatened by OHV activity. In addition, occurrences impacted or threatened by development may be threatened by this activity due to lack of protection from OHV access and close proximity to roads (USFWS, 2009).

Stressor: Manure dumping (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Since listing, manure dumping was recognized by the Service as a threat to 2 of the 4 occurrences of *Brodiaea filifolia* along the San Jacinto River in Riverside County (Service 2005a, p. 73821; Table 1). Dumping of livestock manure results in physical disturbance of the soil surface,

burial of the plants and seed bank, and dilution or alteration of the alkali character of soil or soil chemistry (Roberts, in litt. 2005a, p. 1). These changes create conditions more favorable to invasive nonnative plants that would otherwise be hampered by the higher alkaline nature of the soil (Roberts, in litt. 2005a, p. 1). Although manure dumping threatens *Brodiaea filifolia* where such activity occurs, this threat is localized to certain areas within Riverside County and is not a rangewide threat to the species (USFWS, 2009).

Stressor: Climate change (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: It is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects. One study has predicted that 5 to 10 percent of California's native plant species would no longer find suitable habitat within the state, and thus be vulnerable to extinction, if average temperatures warmed 5–6° F (Morse et al. 1995, p. 393). Whether or not this would include *Brodiaea filifolia* is unknown (USFWS, 2009).

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Recovery Priority Number: 8C

Delisting Criteria:

Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Work with partners to help conserve *Brodiaea filifolia*. Identify opportunities through the Service's Partners for Fish and Wildlife Program to seek habitat restoration and enhancement opportunities. Acquire and protect sites with large or geographically distinct *B. filifolia* occurrences, such as those found at: San Dimas, Arrowhead Hot Springs, the San Jacinto River, Cristianitos Canyon, the undeveloped Darwin parcel, the Upham site, and Artesian Trails (USFWS, 2009).
- Determine the status of management and monitoring, and control on nonnative plants at sites that have been set aside for conservation including, but not limited to: Darwin Knolls and Darwin Glen, Arbor Creek/Colucci, Calavera Heights Mitigation site, FoxMiller, Taylor Made, Rancho Carrillo, and New Millennium (USFWS, 2009).
- Reestablish effective management at sites formerly managed by TET, including the Newton Business Center site and the Mission View/Sierra Ridge site (USFWS, 2009).
- Work with partners to conduct research for the conservation of *Brodiaea filifolia*: a. Determine the home ranges and species fidelity of pollinators of *B. filifolia* and their impact on recruitment. b. Work with Camp Pendleton in the design and implementation of a study investigating soil characteristics that facilitate *B. filifolia* establishment and propagation. c. Work with Rancho Santa Ana Botanic Garden's to design and implement a germination study. d. Determine the relationship of *B. santarosae* to *B. filifolia*, its habitat specificity, and its distribution (USFWS, 2009).

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** To recover *Brodiaea filifolia*, we need to conserve additional habitat and enhance or restore degraded habitat. To accomplish these actions, we also need additional monitoring, surveys, and site assessment across the species' range. We recommend that the following actions be completed over the next 5 years to enhance habitat and manage threats to *B. filifolia*. We recognize that conservation of this species will require cooperation and coordination with partners. 1. Conduct a Species Status Assessment to analyze the species resiliency, redundancy, and representation in light on new occurrences and conservation efforts. 2. Monitor known and historical occurrences to determine presence and condition of *Brodiaea filifolia*. Evaluate threats and develop site-specific recommendations to prioritize management actions. 3. Model suitable habitat across the range of *Brodiaea filifolia* and prioritize areas for further survey. 4. Conduct further research to understand pollinator composition and availability, and the potential effects of low seed set on *Brodiaea filifolia* viability and recovery. 5. Characterize the genetic variation and population structure to understand the level of gene flow between occurrences. Evaluate the extent of hybridization. Conduct phylogenetic studies to determine the relationship to *Brodiaea santarosae*. 6. Develop a reintroduction, augmentation, and translocation program to improve connectivity between populations and enhance the resiliency of small populations. Outline techniques for successful restoration and translocation. 7. Collect *Brodiaea filifolia* seed and corms from occurrences throughout the range and conserve seed in an off-site conservation seed bank or botanic garden as appropriate. 8. Adaptively manage *Brodiaea filifolia* habitat to maintain, enhance, or restore habitat and maintain population viability over time. Use the site-specific recommendations developed under actions 1–3 above, including measures to enhance habitat for native pollinators and ameliorate threats. 9. At *Brodiaea filifolia* occurrences that are not conserved, identify opportunities to work with landowners to acquire lands or encourage conservation actions for *Brodiaea filifolia*. Work with local, State, and Federal partners to identify and leverage funding (i.e., section 6) to acquire occupied and potential habitat. 10. Identify adaptive management and monitoring approaches that could be applied rangewide, especially regarding invasive species management and promoting pollinator habitat. (USFWS, 2023).

References

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

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016

USFWS 2009. *Brodiaea filifolia* (thread-leaved brodiaea) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, California.

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

Final Revised Critical Habitat for *Brodiaea filifolia* (Thread-Leaved Brodiaea). Final Rule. 76 FR 6848-6925 (February 8, 2011).

USFWS 2009. *Brodiaea filifolia* (thread-leaved brodiaea) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, California. USFWS. 2023. *Brodiaea filifolia* (Thread-leaved brodiaea) 5-Year Review: Summary and Evaluation. USFWS.

Carlsbad Fish and Wildlife Office Carlsbad, California. 51 pp.

USFWS. 2009. *Brodiaea filifolia* (thread-leaved brodiaea) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, California.

USFWS. 2023. *Brodiaea filifolia* (Thread-leaved brodiaea) 5-Year Review: Summary and Evaluation. USFWS. Carlsbad Fish and Wildlife Office Carlsbad, California. 51 pp.

SPECIES ACCOUNT: *Brodiaea pallida* (Chinese Camp brodiaea)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/14/1998; Pacific Southwest (R8) (USFWS, 2015)

Physical Description

A perennial herb from an underground bulb. Leaves are narrow, fleshy, reaching 1-3 dm in height. Several to many lilac-colored flowers, each 2 cm across, bloom at the tip of the flowering stem in late May to early June (NatureServe, 2015).

Taxonomy

Grows in association with 2 sympatric congeners and can hybridize with 1 of them (Keator 1993 as cited in USFWS 1994). Despite this, the species is considered stable (Blaine Rogers, Collumbia College, as cited in USFWS 1994) (NatureServe, 2015). A member of the Themidaceae (false onion family) (USFWS, 2012).

Historical Range

This plant species was first discovered in the Town of Chinese Camp in Tuolumne County (USFWS, 2012).

Current Range

Currently occurs in Calveras county and Tuolumne county, CA (USFWS, 2012).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Asexual: vegetative; sexual: cross-pollination (USFWS 2012)

Lifespan

Adult: > 2 years (inferred from USFWS, 2012)

Breeding Season

Adult: May - June (USFWS, 2013)

Key Resources Needed for Breeding

Adult: Germination: unknown; pollination: insects, especially solitary bees (USFWS, 2012)

Reproduction Narrative

Adult: Daughter corms are the primary reproductive units of *B. pallida* (Hoover 1938; R. Ornduff, University of California, Berkeley, California, in litt. 1989; F. Hrusa, California Department of Food and Agriculture, pers. comm. 2000) and are identical genetically to the main (parent) corm. By March, the buds have developed and the flower stalk elongates. However, the flowers do not

open until late May or early June, and flowering lasts only 2 to 3 weeks. The seeds are mature by late summer (Hoover 1939, Niehaus 1971) but probably are not dispersed until the capsule ruptures in the autumn, which is typical of other Californian *Brodiaea* species (Schmidt 1980). Conditions conducive to triggering natural germination are also unknown. Members of the genus *Brodiaea* are self-incompatible and cannot sexually reproduce without the aid of insect pollinators (Niehaus 1971; Preston 2011). Therefore, cross-pollination is essential for the survival and recovery of *B. pallida*. A variety of insects are known to cross-pollinate *Brodiaea*, including native bees (Krombein and Hurd; 1979; Michener 2000) and tumbling flower beetles (Preston 2011). Due to the focused foraging habits of solitary bees, they may be the most important for the successful reproduction of *B. pallida*. As perennial plants, *Brodiaea pallida* individuals persist from year to year (USFWS, 2012).

Habitat Type

Adult: Terrestrial, wetland (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Valley and foothill grassland (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Mesic conditions (inferred from USFWS, 2012)

Geographic or Habitat Restraints or Barriers

Adult: Occurs ~380 m elevation (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Inhabits an old, intermittent (vernal) stream channel with a serpentine substrate; about 380 m elevation. Occurs in valley and foothill grassland (vernal streambeds, serpentinite) (California Native Plant Society 2001). This species requires specific edaphic factors (NatureServe, 2015). *Brodiaea pallida* grows in overflow channels, seeps, and springs in clays that may be derived from serpentine soils (Safford et al. 2005; Service 2008; California Natural Diversity Database (CNDDB) 2011) (USFWS, 2012).

Dispersal/Migration**Dispersal**

Adult: Low (USFWS, 2012)

Dispersal/Migration Narrative

Adult: *Brodiaea* seeds are large and do not disperse far from the parent plants. Therefore the rate of dispersal is very low (USFWS, 2012).

Population Information and Trends

Population Trends:

Declining (USFWS, 2022)

Number of Populations:

3 (USFWS, 2022)

Population Size:

Chinese Camp population ~30 in 2022. Sawmill/Black Creek population ~6,800 in 2017.

Littlejohns Creek population ~112 in 2019 (USFWS, 2023)

Population Narrative:

The number of genetic individuals is unknown because this species spreads by producing suckers and shoots (USFWS 1998). The number of ramets is estimated at around 10,000 individuals (CNDDDB 2003). Only two occurrences exist near Chinese Camp, California in Calaveras and Tuolumne counties (CNPS 2001, CNDDDB 2003). The occurrences of this species are reported to be increasing in numbers (CNDDDB 2003) (NatureServe, 2015). Currently, *B. pallida* is known from three populations. Two of the populations occur in in southern Calaveras County, near Copperopolis California; the other population occurs near Chinese Camp in northern Tuolumne County. The number of genetically unique individuals in the three populations is unknown (USFWS, 2012). 3 populations. Chinese Camp population ~30 in 2022. Sawmill/Black Creek population ~6,800 in 2017. Littlejohns Creek population ~112 in 2019 (USFWS, 2023)

Threats and Stressors

Stressor: Development (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Currently, *B. pallida* is still threatened by development. Additionally, *B. pallida* is potentially threatened by alteration of site hydrology as a result of development. Development projects upslope and adjacent to *B. pallida* populations may dewater the site. Conversely, water runoff from nearby developments may inundate *B. pallida* occurrences with excessive amounts of water, depositing silt, and drowning plants. Residential development outside of the populations themselves could indirectly affect the habitat for *B. pallida* in both counties by modifying stream contours during the construction of roads (Hrusa, pers. comm. 2000; Stone, pers. comm. 2001) or firebreaks (CNDDDB 2006), and by altering hydrology in adjacent streams. Only a small part of the Tuolumne County site receives some level of protection through a temporary lease by an environmental organization, and residential development for another part of the site has been planned in the past and is not precluded for the future. The Calaveras County populations are being designated and considered for residential development (USFWS, 2009).

Stressor: Small population size (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Small population size increases the susceptibility of a population to extirpation from random demographic, environmental, and/or genetic events (Service 1998). The combination of

only two populations, small range, and restricted habitat still renders *B. pallida* highly susceptible to extinction from a significant portion of its range due to random events such as flood, drought, disease, or other factors. Another concern is the possible lack of genetic diversity in the two *Brodiaea pallida* populations due to the species' tendency toward vegetative reproduction (Ornduff, in litt. 1989). The preponderance of vegetative reproduction in *B. pallida* may limit the opportunities for production of new genotypes, and the great physical distance (about 24 kilometers [15 miles]) between the two known populations likely precludes the opportunity for natural transfer of pollen, seeds, or corms between them (USFWS, 2012).

Stressor: Nonnative vegetation (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Increased nitrogen deposition initially causes ecological perturbations by altering microbial and plant communities. One of the primary adverse effects is the enhancement of environmental conditions for the invasion of non-native weeds, which outcompete native plants (Padgett et al. 1999; Allen et al. 2005), particularly star thistle and non-native grasses such as rip-gut brome. These invasive exotic plants "choke out" native plants through extensive proliferation, and significantly reduce the available area for colonization of native plant species and ground-nesting pollinators. Weeds also grow so densely that *Brodiaea pallida* may not easily be found by its pollinators. Nitrogen deposition also affects the natural fire cycle because of greater fuel loads caused by the excess growth of non-native grasses and weeds (D'Antonio and Vitousek 1992). Nonnative vegetation occurs in at least two of the populations (ICF Jones & Stokes 2009; CNDDB 2011) (USFWS, 2012).

Stressor: Loss of pollinators (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: A number of the native bee species that pollinate *Brodiaea pallida* could be adversely affected by insecticides and other pesticides associated with the Oak Canyon Ranch or other developments. A number of the solitary, semi-solitary, or colonial bees that pollinate this plant make their nests in the ground, and they could be vulnerable to toxic chemical agents that are the result of runoff from the proposed project. Their ground nests also could be adversely affected by increased seasonal flows, especially summer flows that could flood out the animals, thus eliminating or preventing these insects from inhabiting the area (USFWS, 2012).

Stressor: Climate change (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Ongoing climate change (Inkley et al. 2004; Kerr 2007; Adger et al. 2007; Kanter 2007) likely imperils *Brodiaea pallida* and the resources necessary for its survival. Since climate change threatens to disrupt annual weather patterns, it may result in a loss of its habitat and/or increased numbers of its predators, parasites, and diseases. Where populations are isolated, a changing climate may result in local extinction, with range shifts precluded by lack of habitat, or in the case of plants the inability to disperse at a rate equal to the change in environmental conditions (USFWS, 2012).

Stressor: Grazing (USFWS, 2022)

Exposure:

Response:

Consequence:

Narrative: In the final listing rule as well as in the subsequent status reviews, we noted that it is unclear whether grazing is beneficial or detrimental to Chinese Camp brodiaea (Service 1998, p. 49029; Service 2008, pp. 6–7; Service 2012, p. 9). Observation of herbivory are for the most part assumed to be from grazing, although it is also possible that herbivory by deer or other herbivores could impact the species. At this time, it appears that at least some level of grazing is likely beneficial to the species, but that herbivory between flowering and seed set could greatly impact sexual reproduction. The effects on plants from livestock grazing are highly variable and dependent on many factors, including but not limited to the timing, intensity, and duration of livestock use. Negative impacts from grazing include direct consumption and habitat trampling. Grazing during flower development or blooming season could result in direct consumption of the above-ground parts of the plant (Niehaus 1977, p. 1), which can reduce or eliminate seed output. The potential for this to affect the species would be related to the grazing intensity, or the number of cattle or other livestock in an area. Although the primary method of propagation is asexual reproduction via corms, seed production is important for genetic diversity. Reduction in seeds could lead to short-term decreases in new growth, as well as limiting the ability of the species to produce a seedbank. Grazing can also result in trampling or soil compaction. While trampling from livestock could result in soil compaction, accelerated erosion of soils, and breaking of corms, the severity and magnitude of this stressor at any of the three known occurrences is unknown at this time. Trampling can also affect habitat by reducing rainfall infiltration rates (Warren et. al. 1986, pp. 493-494). Although moderate-intensity cattle grazing at the Sawmill/ Black Creek location in 2008 was not thought to be having an adverse effect on Chinese Camp brodiaea plants (ICF Jones & Stokes 2009, p. 4), in 2017 severe damage to Chinese Camp brodiaea was noted (Brenneman in litt. 2017). Of the 6,800 plants counted in June of 2017, only 50 to 60 plants were counted in July of that year. At that time, the only surviving plants were found among the tall boulders inaccessible to grazing cattle. While grazing at an inappropriate time or intensity can result in damaging effects to Chinese Camp brodiaea and its habitat, as stated above, it is possible for grazing to occur in a manner that supports and even encourages growth of Chinese Camp brodiaea. In areas that contain both Chinese Camp brodiaea and non-native plants, grazing that occurs after seed has matured and before substantial leaf emergence/flower development may be beneficial in reducing competing vegetation. The consumption and removal of non-native plants would increase bare soil areas, sunlight exposure, and access to water and minerals. In April 1991, The Nature Conservancy and the Plant Society purchased and installed fencing and gates surrounding the Chinese Camp brodiaea population at Chinese Camp to protect the population from the effects of grazing (Lozier in litt. 1991; Stone in litt. 2001). At that time, the Plant Society also entered into a lease agreement with the landowner, paying him to exclude his cattle from the area for one year. Though to our knowledge this agreement has ended, the area is still ungrazed and the fencing and gates remain. The area has experienced an increase in weedy species such as barbed goatgrass (*Aegilops triuncialis*), wild oat (*Avena fatua*), tarweed (*Hemizonia* spp.), and spikeweed (*Centromadia pungens*) in recent years (Congdon in litt. 2018). Though annual trend data are not available, it is likely that the removal of cattle at the Chinese Camp population precipitated the increase in these non-native invasive plants and a decrease in Chinese Camp brodiaea. Therefore, it is likely that appropriate grazing, managed to reduce competing non-native plants, may have a beneficial effect on the

species at the Chinese Camp site (USFWS, 2022).

Stressor: Development (USFWS, 2022)

Exposure:

Response:

Consequence:

Narrative: Because all three Chinese Camp brodiaea populations are located on privately owned lands that are vulnerable to development impacts, with no provision for protection or management, development continues to be a threat. The General Plans for both Calaveras County and Tuolumne County were updated in November 2019 and December 2018, respectively (Calaveras County 2019, entire; Tuolumne County Community Resources Agency 2018, entire). Potential development in Calaveras County threatens both populations in that area. Black Creek Ranch, which contains the Sawmill/Black Creek population, was slated for development as of the last status review (Service 2012, p. 8). The property was recently sold to a different developer that plans to proceed with residential development on the hilltops surrounding the plants (Lewis in litt. 2020). Portions of the property that contain Chinese Camp brodiaea will not be developed according to the most recent plans, but the plant could still be affected by any increased run-off or irrigation. Also in Calaveras County, Sawmill Lake is a planned future community that consists of a 245-acre extension to the Copperopolis Town Square upstream of the Chinese Camp brodiaea occurrences and Copper Valley Ranch is a future community that is being developed on the North Shore of Lake Tulloch. An online website (Copper Valley Realty 2020) that has since been removed included detailed information about the type of residential units planned for the development; however, that information is no longer available and we are not aware of the current status of this project. A motion to amend the land use of Copper Valley from Resource Production to Working Lands, which would allow increased residential development of those lands, was voted down at a June 2019 planning commission meeting (Calaveras County Planning Commission 2019). Overlaying the Calaveras County General Plan with Diversity Database occurrences of Chinese Camp brodiaea shows that the Sawmill/Black Creek population occurs on lands labeled as Resource Production, Working Lands, and Rural Residential, and that the Littlejohns Creek population is on parcels labeled as Working Lands and Resource Production (Calaveras County Open Data 2021). Descriptions of the land use designations are provided in the general plan (Calaveras County 2019, pp. LU5–LU7). Briefly, Resource Production identifies lands capable of and primarily used for agricultural operations, timber production and/or mineral resource production, and also includes lands with conservation easements. Working Lands have a slightly higher population density than Resource Production (0.06–0.12 person/acre compared to 0.015–0.06 person/acre) and are generally on smaller parcels than lands designated as Resource Production, but are still suitable for agricultural and forestry practices. The Rural Residential designation identifies rural residential uses in areas appropriate for or that were previously subdivided into lots of one acre or larger where public sewer is not available. The development agreement for the Oak Canyon Ranch development project (upstream of the Black Creek/Sawmill Creek and Littlejohns Creek populations) that was described in the previous status review (Service 2012, pp. 7–8) was rescinded in 2018. Oak Canyon Ranch is now under conservation easement (California Rangeland Trust 2020) (see Land protection below). In Tuolumne County, proposed development projects described in the previous status review (Service 2012, p. 8) include development of 93 hectares (230 acres) at a private ranch, as well as an unnamed project at the junction of Highway 108 and Highway 120. The private ranch includes Chinese Camp brodiaea on the property, while the latter project could have potential impacts to hydrology. In 2016, the Tuolumne County Planning Department reported that both of these projects were on

hold because of a lack of water accommodations (Paszkowski pers. comm. 2016). As of 2021, there is no active project for development at the private ranch. The Highway 108/120 junction project requires an Environmental Impact Report and there is no date or timeline for the project moving forward (Rizzi in litt. 2021) (USFWS, 2022).

Stressor: Altered hydrology (USFWS, 2022)

Exposure:

Response:

Consequence:

Narrative: Changes to the amount and/or inundation period of water in, upstream, or adjacent to Chinese Camp brodiaea habitat could impact the species. These changes could occur through a variety of mechanisms including, but not limited to, development, land use changes, increases in the frequency and severity of precipitation events associated with climate change (both deluges and droughts), and vegetative community changes. Development can lead to increased flows if irrigation or other sources discharge into streams, or can reduce flows if water is diverted away from the natural flow. For example, summer irrigation or upstream drainage (Tuolumne County Planning Department 1982, p. 3), or damming of a stream (Hrusa pers. comm. 2000 in Service 2008, p. 6) could lead to perennially wet conditions and prevent required drying of the soils supporting Chinese Camp brodiaea. Vegetation impeding drainage through a culvert near the Chinese Camp population has been observed in association with ponding above that area, which could make that habitat unsuitable for Chinese Camp brodiaea if excessive inundation causes corms to rot (Congdon in litt. 2020). Land has been increasingly converted to cannabis farms in Calaveras and Tuolumne Counties, which can also alter hydrology. Land converted to this use, especially when irrigation water is illegally diverted from natural waterways, has the potential to impact Chinese Camp brodiaea habitat. The Calaveras County Board of Supervisors legalized commercial cannabis cultivation for approximately 190 formerly registered growers in 2018, despite objections from some that the county's environmental impact report does not address foreseeable impacts to water resources (Calaveras Enterprise 2019). Information has not been gathered to date on the total amount of water used, the extent of fertilizer and pesticide use, and the extent of habitat destroyed by cannabis cultivation. In Tuolumne County, commercial grows of cannabis are not legal (Tuolumne County 2021). A personal grow cannabis ordinance that passed in 2018 requires those planning outdoor grows to register for a permit and limits the number of plants allowed (Tuolumne County 2018, pp. 17-166–17-168). Increases in greenhouse gas emissions during the 20th century have already resulted in global climate change characterized by: warming atmospheric and ocean temperatures, diminishing snow and ice, and rising sea levels (Intergovernmental Panel on Climate Change 2014, pp. 2–3). Climate change in the Sierra Nevada region specifically is predicted to lead to increases in temperature and extreme precipitation events (i.e., both deluges and droughts); a change in the elevation of transition from rainfall to snow, and more rainfall instead of snow at higher elevations; and substantial decreases in snowpack. Because the watersheds containing Chinese Camp brodiaea habitat are influenced by local rainfall rather than snowmelt (Preston in litt. 2020), changes to snowfall and snowpack are unlikely to impact the species. The increase in precipitation extremes (i.e., both deluges and droughts) may have a bigger impact on Chinese Camp brodiaea populations than the changes in average rainfall and snowfall (USFWS, 2022).

Stressor: Hybridization (USFWS, 2022)

Exposure:

Response:

Consequence:

Narrative: A potential future threat to the species is hybridization with harvest brodiaea (*Brodiaea elegans*), a related native species common on drier ground (Niehaus 1971, p. 54). Because we have no information that hybridization is currently spreading or causing a trend towards endangerment or extinction, we do not consider hybridization a current threat to the species; however, additional information about current trends or increases in the extent or areal coverage of hybrids could change this assessment. Hybridization could be a potential threat in the future because harvest brodiaea is associated with drier habitat and altered hydrology that reduces stream flow could theoretically increase populations of hybrids. Hybrids can be distinguished from either of the two parent species by their appearance. Specifically, Chinese Camp brodiaea have staminodes near stamens and are not appressed to tepals, giving a “waist-like” appearance, whereas harvest brodiaea have staminodes held away from stamens and appressed to tepals (no waist); hybrids are intermediate between the two in these respects (Congdon in litt. 2020). At the time of listing, the Service specified that it was not listing hybrids between Chinese Camp brodiaea and harvest brodiaea (Service 1998, p. 49022). To our knowledge all hybrids occur in the immediate vicinity of the Chinese Camp population of Chinese Camp brodiaea. Surveys in 2017 for Chinese Camp brodiaea at Chinese Camp found that predominantly hybrids appeared to be present within the Plant Society fenced area (Congdon in litt. 2017c), but in 2018 there were more Chinese Camp brodiaea than hybrids (Congdon in litt. 2018). Harvest brodiaea is common at that site, but uncommon at the sites in Calaveras County (USFWS, 2022).

Recovery**Reclassification Criteria:**

Not available - this species does not have a recovery plan.

Recovery Priority Number: 2C

Delisting Criteria:

Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Work with private landowners to determine the entire extent of the extant populations and monitor the status and trends of *Brodiaea pallida* in order to estimate current population sizes (i.e., number of above-ground stems), the number and distribution of populations, and whether the species is stable, increasing, or declining (USFWS, 2012).
- Seed collection and accession. Collect mature seed during a minimum of two years from the Sawmill Creek and Black Creek population (and if possible from the Littlejohns Creek population). Collect seed from no more than 5 percent of plants at each population in each year and store in at least two locations approved by the Service in the event that the population(s) fails. Eventually reach a goal of 1,000 stored seeds. Seed storage locations should be affiliates of the Center for Plant Conservation. Collection of seed shall be conducted in a manner that will not significantly harm the reproductive potential of the population for that year and shall be made in a manner that captures the majority of the genetic variation found in the sampled population. Different genotypes or seed from different occurrences shall not be intermingled during collection or storage activities

(USFWS, 2012).

- Continue surveying for *Brodiaea pallida* in suitable habitats on substrates other than serpentine to determine if additional populations exist (USFWS, 2012).

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS:** Here we propose several habitat conservation and ecological research recommendations which will aid in the recovery and conservation of Chinese Camp *brodiaea*. Some of these recommendations have already been discussed in previous recovery documents (Service 2008, pp. 9–10; Service 2012, p. 15) and remain valid. 1. Complete and publish a draft recovery plan, and approve a final recovery plan. The recovery plan will likely contain additional information about many of the elements described in the recommendations below. 2. Habitat protection. Work with private landowners to provide permanent protection for lands upstream and occupied by Chinese Camp *brodiaea*. 3. Habitat management. Work with private landowners and partners to implement habitat management practices that benefit Chinese Camp *brodiaea*. Volunteers from the Plant Society have expressed interest in helping to maintain the Plant Society fenced area (e.g., pulling weeds) given appropriate guidance from species experts and support from the land owner (Krajnovich in litt. 2021b). 4. Monitor known populations. Work with private landowners to determine the entire extent of the extant populations and monitor the status and trends of Chinese Camp *brodiaea* in order to estimate current population sizes (i.e., number of above-ground stems), the number and distribution of populations, and whether those populations are stable, increasing, or declining. 5. Seed collection and accession. Work with private landowners to obtain permission for seed collection if possible. Collect mature seed over a minimum of two years from the Sawmill Creek/Black Creek and Littlejohns Creek populations. Collect seed from no more than 5 percent of plants at each population in each year and store in at least two locations approved by the Service in the event that the population(s) fails. Seed storage locations should be affiliates of the Center for Plant Conservation and seed collection should follow best plant conservation practices (Center for Plant Conservation 2019). 6. Survey for additional populations. Continue surveying for Chinese Camp *brodiaea* in suitable habitats on substrates other than serpentine to determine if additional populations exist (USFWS, 2022).

References

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

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016

USFWS 2012. *Brodiaea pallida* (Chinese Camp *Brodiaea*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California. USFWS. 2022. Chinese Camp *Brodiaea* (*Brodiaea pallida*) 5-Year Review: Summary and Evaluation. USFWS. Sacramento Fish and Wildlife Office Sacramento, California. 12 pp.

USFWS 2012. *Brodiaea pallida* (Chinese Camp *Brodiaea*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California.

USFWS. 2012. *Brodiaea pallida* (Chinese Camp *Brodiaea*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California.

USFWS. 2022. Chinese Camp *Brodiaea* (*Brodiaea pallida*) 5-Year Review: Summary and Evaluation. USFWS. Sacramento Fish and Wildlife Office Sacramento, California. 12 pp.

SPECIES ACCOUNT: *Bulbophyllum guamense* (Cebello halumtano)

Species Taxonomic and Listing Information

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

Physical Description

An epiphyte (USFWS, 2015).

Taxonomy

A member of the orchid family (Orchidaceae) (USFWS, 2015).

Historical Range

It occurred historically on Pagan, *Bulbophyllum guamense* was recorded historically on Guam from clifflines encircling the island, and on the slopes of Mt. Lamlam and Mt. Almagosa (USFWS, 2015).

Current Range

It is known from widely distributed occurrences on the southern Mariana Islands of Guam and Rota (Ames 1914, p. 13; Raulerson and Rinehart 1992, p. 90; Costion and Lorence 2012, pp. 54, 66; Global Biodiversity Information Facility (GBIF) 2012a—Online Herbarium Database; Zarones et al. 2015c, in litt.) (USFWS, 2015). Distribution: Saipan, Guam, Rota, Pagan (USFWS, 2020b).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproduction Narrative

Adult: Not available

Habitat Type

Adult: Terrestrial; arboreal (USFWS, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Forest (USFWS, 2015)

Habitat Narrative

Adult: It occurs in the forest ecosystem (USFWS, 2015).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Not available

Species Trends:

Guam: declining (USFWS, 2015)

Number of Populations:

12 (USFWS, 2020b). ~9 (USFWS, 2020)

Population Size:

1,021 (USFWS, 2020b). ~700 (USFWS, 2020)

Population Narrative:

Currently, there are 12 known occurrences (3 on Guam and 9 on Rota) totaling fewer than 250 individuals on Guam and at least 261 individuals on Rota. *Bulbophyllum guamense* has declined in number of populations and individuals on Guam (USFWS, 2015).

Threats and Stressors

Stressor: Development, military training, and urbanization (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: In their 2015 Final SEIS ([http:// guambuildupeis.us/](http://guambuildupeis.us/)), the U.S. Department of Navy states that approximately 5,000 Marines will be relocated from Okinawa to Guam, accompanied by approximately 1,300 dependents, with a concurrent introduction of support staff and development of infrastructure, and increased use of resources such as water (Berger et al. 2005, p. 347; JGPO– NavFac, Pacific 2015, p. ES–3). The current preferred alternative sites on Guam for cantonment and live-fire training include the Naval Computer and Telecommunications Station Finegayan and Northwest Field on Andersen AFB, where this species is known to occur. In November 2007, the people of Rota voted to legalize casino gambling to increase tourism, and two development projects have been proposed. First, the Treasure Island Casino, which will build upon the existing Rota Hotel (CNMI Tourism Master Plan 2012, pp. 128–129; Zotomayor 2014, in litt.); and second, a casino designed around the existing Rota Resort and Country Club. Rota currently has seven operational hotels, and tourism is one of the island’s primary industries, although a lack of reliable transportation currently limits the amount of visitors (CNMI Tourism Master Plan 2012, pp. 128–129). Development around and within forested areas on Rota will also directly impact the forest habitat and individuals of this species (USFWS, 2015).

Stressor: Fire (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: Fire is a human-exacerbated threat to native species and native ecosystems throughout the Mariana Islands, particularly on the island of Guam. Fire can destroy dormant seeds of native species as well as plants themselves, even in steep or inaccessible areas. Successive fires that burn farther and farther into native habitat destroy native plants and

remove habitat for native species by altering microclimate conditions to those favorable to alien plants (USFWS, 2015). Wildfires plague forest and savanna areas on Guam every dry season despite the island's humid climate, with at least 80 percent of wildfires resulting from arson (JGPO–NavFac, Pacific 2010b, p. 1–9).

Stressor: Slug predation (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: The nonnative Cuban slug (*Veronicella cubensis*) is considered one of the greatest threats to native plant species on Pacific Islands (Robinson and Hollingsworth 2006, p. 2). These terrestrial mollusks are generalist feeders, and can attack a wide variety of plants, and switch food preferences if potential food plants change (Robinson and Hollingsworth 2006, p. 2). In addition, these slugs are known to attack orchids, which puts this species at risk from slug predation (USFWS, 2015).

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Delisting Criteria:

Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- A conservation project on Rota, administered through the Water and Environmental Research Institute of the Western Pacific at the University of Guam, is aimed to analyze the island's hydrology, with the ultimate goal of protection of the Sabana Watershed and Talakhaya Springs (Keel et al. 2007, pp. 5, 22–23). Erosion control, revegetation, and water source preservation conducted as part of this project may provide protection to this species (USFWS, 2015).
- Threat and Recovery Potential: Full species with a moderate degree of threat and a high recovery potential. (USFWS, 2020b)

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** • Surveys and inventories—Continue to survey for *B. guamense* in historical locations and potentially suitable habitat. • Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species and those that compete with *B. guamense* or modify their habitat. • Fire monitoring and control—Develop and implement fire prevention management plans. • Captive propagation for genetic storage and reintroduction—Collect seeds for storage and propagation efforts for maintenance of genetic stock. • Ungulate predation or herbivory—Construct ungulate exclosures, or erect strategic fencing, around naturally occurring *B. guamense* populations to protect this species and associated habitat from feral ungulates. • Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change • Alliance and partnership development—Initiate planning and contribute to implementation of ecosystem-level restoration and management, especially between Guam and the CNMI to benefit this taxon. • Research life history and habitat

associations to better identify information that will help guide recovery, for example: specific micro-habitat conditions, pollinators, reproduction, etc. (USFWS, 2020)

- Current Management Actions:
 - Surveys and inventories:
 - o *Bulbophyllum guamense* are surveyed for in suitable habitat that may be cleared or degraded for various projects.
 - o Joint Region Marianas (JRM) surveyed for ESA-listed species, including *B. guamense*, at the Naval Munitions Site (NMS) and Naval Base Guam Telecommunication Site. Surveys were conducted to document locations and estimate population densities in sites that are proposed for ungulate exclusion and forest restoration (JRM 2019).
 - Captive propagation for genetic storage: The Guam Plant Extinction Prevention Program (GPEPP) stores propagules of *B. guamense* to preserve genetic variability and protect the species from catastrophic events that may result in the species' extinction. Currently, GPEPP has approximately 13,000 *B. guamense* seedlings in flasks. Germination of *B. guamense* via tissue culture has been more successful than establishing individuals in the nursery.
 - Habitat protection:
 - o An island-wide Habitat Conservation Plan for Guam, that would provide a collaborative and comprehensive approach to endangered species conservation on non-federal lands, is beginning to be developed (USFWS 2020).
 - o A 2020 Memorandum of Understanding between JRM and the USFWS outlined a mutual understanding regarding the intentions and future considerations of a Department of Defense Readiness and Environmental Protection Integration Initiative (REPI) to address conservation of upland vegetation communities (DON and USFWS 2020).
 - o Native forest ecosystems are being restored in multiple plots on the NMS within fenced areas where ungulates and invasive plants have been removed (JRM 2019).
 - o Plans to exclude deer and pigs from 165 acres of North Haputo Ecological Reserve Area with ungulate fencing have been developed (USFWS 2017).
 - Habitat protection/Ordinance: Range Fire Management Plan for Marine Corps Ranges on Guam. A range fire management plan to reduce range/wildfire potential, protect and enhance natural and cultural resources, integrate applicable permit and reporting requirements and implement ecosystem management goals, sustainable training, and objectives already supported on existing Marine Corps installations is being drafted. (USFWS, 2020)

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS 2015. Endangered and Threatened Wildlife and Plants

Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497. USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497.

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497. USFWS. 2020. *Bulbophyllum guamense* (Siboyan halom tano

Siboyas halumtano). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. 17 pp. USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

USFWS. 2015. Endangered and Threatened Wildlife and Plants

USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

USFWS. 2020. *Bulbophyllum guamense* (Siboyan halom tano

Siboyas halumtano). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. 17 pp.

SPECIES ACCOUNT: *Calamagrostis expansa* (Maui reedgrass)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/31/2016; Pacific Region (R1) (USFWS, 2016)

Physical Description

Calamagrostis expansa, a member of the Poaceae (grass) family, is a short, rhizomatous (with horizontal underground stems) perennial grass. Culms (aerial stems) are erect or sometimes decumbent (close to the ground), 50 to 200 centimeters (cm) (1.6 to 6.6 feet (ft)) tall and 4 to 8 millimeters (mm) (0.2 to 0.3 inches (in)) in diameter. Sheaths surrounding the stems overlap closely along the middle of the culm; the ligule (ring at the junction of the blade and the sheath) is 3.5 to 4 mm (0.14 to 0.16 in) long and blades are flat to involute, 15 to 20 cm (5.9 to 7.9 in) long and 1 to 3 cm (0.4 to 1.2 in) wide. Densely scabrous (rough) inflorescences are 15 to 30 cm (6 to 12 in) long with no spikelets (ultimate flower cluster) on the lower half. The rachilla (spikelet axis) is 1.5 to 2 mm (0.06 to 0.08 in) long with whitish yellow silky hairs up to 1 cm (0.4 in) long. The pale brown ovoid caryopsis (fruit), up to 2.5 mm (0.1 in) long, is slightly grooved ventrally (O'Connor 1999, p. 1509) (USFWS, 2021b).

Taxonomy

Kingdom: Plantae; Phylum: Anthophyta; Class: Monocotyledoneae; Order: Cyperales; Family: Poaceae (Grasses). *Calamagrostis expansa* is a wild grass described by A.S. Hitchcock (1922, p. 148). This species is recognized as a distinct taxon in O'Connor (1999, p. 1,509) and in Wagner and Herbst (2003, p. 59). *Calamagrostis expansa* was first described by Munro in 1862 and later by Hillebrand in 1888 under the name *Deyeuxia expansa* from a type specimen collected in the 1800s (during the Wilkes Expedition) from the northern slopes of Haleakalā Crater on east Maui (Munro 1862 in Hillebrand 1888, p. 519; U.S. Exploration Expedition 1883–1842, in litt.). The species was re-described by Hitchcock moving it from the genus *Deyeuxia* to *Calamagrostis* (Hitchcock 1926, p. 149). *Calamagrostis expansa* is the currently recognized taxonomy (O'Connor 1999, p. 1509; Herbst and Clayton 1998 in Wagner et al. 2012, p. 90). (USFWS, 2021b).

Historical Range

Historically rare, *Calamagrostis expansa* was reported from wet forest and bogs on Maui (O'Connor 1999, p. 1,509). Discovered on the island of Hawaii in 1995, the historical status of the species on this island is unknown (HBMP 2008). Historically, *Calamagrostis expansa* occurred in the west and east Maui mountains and on the island of Hawai'i in the Kohala mountains. On east Maui, *C. expansa* was known from the wet upland areas of Haleakalā at Pi'ina'au-Ke'anae-Honomanū (U.S. Exploration Expedition 1838–1842). On west Maui, occurrences were known at Pu'u Kukui, Honokōhau, and 'Eke Crater (Ewart 1928, in litt.; St. John 1930, in litt.; Herbst 1968, in litt.; Higashino 1976, in litt.; Hobby 1979, in litt.) (USFWS, 2021b).

Current Range

Currently, *Calamagrostis expansa* is found on the islands of Maui and Hawaii, in wet forest, open bogs, and bog margins (HBMP 2008). Maui (extant); Hawai'i (likely extirpated) (USFWS, 2021). Distribution: Maui (extant); Hawai'i (possibly extirpated) (USFWS, 2022)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Likely wind pollinated (USFWS, 2021b)

Lifespan

Adult: Short (USFWS, 2022)

Breeding Season

Adult: year round (USFWS< 2021b)

Reproduction Narrative

Adult: The life history characteristics of *Calamagrostis expansa* have not been well studied. The pollination of *C. expansa* is unknown but wind is the presumed pollination mechanism for a related Hawaiian *Calamagrostis* species; therefore, wind is the presumed pollination mechanism for *C. expansa* (Sakai et al. 1995, p. 2527). Herbarium collections from Maui and the island of Hawai'i show flowering and fruiting nearly year-round (Ewart III 1928, in litt.; Forbes 1917, 1919, in litt.; Harrison 1973, in litt.; Herbst and Bishop 1968, in litt.; Higashino 1976, in litt.; Hobdy 1979, in litt.; Munro 1916, 1927, in litt.; NTBG 2020; Oppenheimer et al. 2010, in litt; St. John 1930, in litt; Wood and Perlman 1995, in litt.). The seeds of *C. expansa* are described as having slender teeth, which may aid in attachment to bird feathers for transport and dispersal (Sakai et al. 1995, p. 2524, 2527; O'Connor 1999, p. 1509). The results of a germination test indicated 26 percent viability initially and seeds germinated for a year after sowing (Lyon Arboretum 2020). (USFWS, 2021b).

Habitat Type

Adult: *Calamagrostis expansa* occurs within four habitat types: wet forest, wet grassland and shrubland, and montane riparian and bog habitat (USFWS, 2021b)

Habitat Vegetation or Surface Water Classification

Adult: Palustrine Habitats: Bog/fen; forested wetland

Dependencies on Specific Environmental Elements

Adult: Occurs at 1,217 to 2,032 meters (m) (3,993 to 6,668 feet (ft)) elevation (USFWS< 2021b).

Environmental Specificity

Adult: Very narrow to narrow

Habitat Narrative

Adult: *Calamagrostis expansa* is found in wet forest, open bogs, and bog margins. On Maui, *C. expansa* is found with the associated species *Carex echinata* (no common name (NCN)), *Cheirodendron trigynum* (olapa), *Deschampsia nubigena* (hairgrass), *Dicranopteris linearis* (uluhe), *Dryopteris* spp. (laukahi), *Dubautia* spp. (naenae), *Leptecophylla tameiameia* (pukiawe), *Lysimachia* spp. (NCN), *Machaerina* spp. (uki), *Metrosideros polymorpha* (ohia),

Oreobolus furcatus (NCN), *Rhynchospora* spp. (kuolohia), *Sadleria* spp. (amauu), *Vaccinium* spp. (ohelo), and various ferns, at elevations between 4,000 and 7,500 ft (1,219 and 2,286 m). On the island of Hawaii, *C. expansa* is found in *Metrosideros polymorpha*-*Machaerina angustifolia* (ohia-uki) montane bogs with the associated species *Cheirodendron trigynum*, *Machaerina angustifolia*, *Metrosideros polymorpha* var. *incana*, and *Rhynchospora* spp., at elevations between 4,200 and 4,442 ft (1,280 and 1,354 m) (OConnor 1999, p. 1,509; Hawaii Biodiversity and Mapping Program (HBMP) 2008). *Calamagrostis expansa* occurs within four habitat types: wet forest, wet grassland and shrubland, and montane riparian and bog habitat at 1,217 to 2,032 meters (m) (3,993 to 6,668 feet (ft)). In general, the soil types where *C. expansa* occurs are well drained to poorly drained usually with a midsoil layer of clay on top of lava flow, igneous rock or an “iron stone” substrate. The soils are usually acidic in nature. The presence of the clay layer and a solid substratum in a wet montane environment is indicative of bogs. *Calamagrostis expansa* populations on the island of Hawai‘i generally occur in 5 to 13 cm (2 to 5 in) soil depths with a pāhoehoe lava flow substratum or a clay type and ironstone layers. On east and west Maui, *C. expansa* generally occurs in very thin to well-developed soils of 3 to 25 cm (2 to 10 in) over a layer of clay and a cinder, stony and rock substratum that is indicative of the older age of the island (Harrington et al. 2019, pp. 8–9). (USFWS, 2021b).

Dispersal/Migration

Dispersal

Adult: Seeds likely dispersed by birds (USFWS, 2021b)

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Number of Populations:

7 (USFWS, 2022)

Population Size:

200 (USFWS, 2022)

Population Narrative:

This species is known from 13 populations numbering fewer than 750 individuals observed during surveys conducted as recently as 2010. We are unaware of additional surveys conducted to date. On the island of Maui, there are two populations totaling approximately 100 individuals in the west Maui mountains at Eke Crater and from Honokohau to Kahoolewa, and seven populations of about 200 individuals in the East Maui mountains, at Waikamoi Preserve, along the southern boundary of Hanawi NAR and Kalapawili Ridge, along the southern rim of Kipahulu Valley, and at New Greensword Bog (Wood, in litt. 2005; Welton, in litt. 2008, Fay, in litt. 2010; Oppenheimer, in litt. 2010; Welton, in litt. 2010; Agorastos, in litt. 2011). On the island of Hawaii, there are three populations in the Kohala FR and Puu o Umi NAR in the Kohala Mountains, totaling approximately 350 individuals (HBMP 2008). There is one small population

in the Upper Waiakea FR, with six individuals observed in 2006 (Perry, in litt. 2006; HBMP 2008). 7 populations. 200 individuals (USFWS, 2022).

Threats and Stressors

Stressor: Feral pigs

Exposure:

Response:

Consequence:

Narrative: *Calamagrostis expansa* is highly and imminently threatened by feral pigs (*Sus scrofa*) on Maui and the island of Hawaii. Evidence of the activities of feral pigs has been reported in areas where *C. expansa* populations are known to occur in the east Maui mountains and also in the Kohala Mountain and Upper Waiakea populations on the island of Hawaii (USFWS 1995; Hobdy, in litt. 1996; Medeiros, in litt. 1996; Perlman, in litt. 1996; Wood, NTBG, in litt. 1996; Perry, in litt. 2006; HBMP 2008). Rooting by feral pigs was observed to be related to the search for earthworms, with rooting depths averaging 8 in (20 cm) greatly disrupting the leaf litter and topsoil layers and contributing to erosion and changes in ground topography (Diong 1982, pp. 143-150). The feeding habits of pigs are observed to create seed beds, enabling the establishment and spread of weedy species such as *Psidium cattleianum* (strawberry guava) (Diong 1982, pp. 164-165). All aspects of the food habits of pigs are damaging to the structure and function of the Hawaiian forest ecosystem (Diong 1982, pp. 166-167). Hawaiian ecosystems, having evolved without hoofed mammals, are susceptible to large-scale disturbance by pigs and other introduced ungulates (Loope et al. 1991, p. 3). Because of demonstrated habitat modifications by feral pigs, such as destruction of native plants, disruption of topsoil leading to erosion, and establishment and spread of nonnative plants, the U.S. Fish and Wildlife Service (FWS) believes they are threats to *C. expansa*.

Stressor: Nonnative plants

Exposure:

Response:

Consequence:

Narrative: The original native flora of Hawaii consisted of about 1,400 species, nearly 90 percent of which were endemic. Of the current total native and naturalized Hawaiian flora of 1,817 taxa, 47 percent are introduced species, and nearly 100 of those species are considered pests (Smith 1985, p. 180; Wagner et al. 1999, p. 45). Confirmed personal observations (HBMP 2008) and several studies (Cuddihy and Stone 1990, p. 74; Wood and Perlman 1997, p. 18; Robichaux et al. 1998, p. 4) indicate nonnative plant species may out-compete native plants similar to *C. expansa*. Competition may be for space, light, water, or nutrients, or they may produce a chemical that inhibits the growth of other plants (Smith 1985, p. 227-230; Cuddihy and Stone 1990, p. 74). In addition, nonnative pest plants found in habitat similar to that of this species have been shown to make the habitat less suitable for native species (Smith 1985, pp. 240-241; Loope and Medeiros 1992, pp. 7-8; Medeiros et al. 1992, p. 30; Ellshoff et al. 1995, pp. ii, 3-4; Meyer and Florence 1996, p. 778; Medeiros et al. 1997, pp. 23-24; Loope et al. 2004, p. 1,472). Nonnative pest plant species degrade habitat by modifying availability of light, altering soil-water regimes, modifying nutrient cycling, or altering fire characteristics of native plant communities (Smith 1985, pp. 227-230; Cuddihy and Stone 1990, p. 74; Vitousek et al. 1997, pp. 6-10). Because of demonstrated habitat modification and resource competition by nonnative plant species in habitat similar to that of *C. expansa*, the FWS believes nonnative plant species are a threat to this

species.

Recovery

Reclassification Criteria:

Recovery Priority Number = 5 (USFWS, 2022) Number of populations and individuals needed for each plant species to meet the preventing extinction stage based on population and life history characteristics. Number of Populations = 3. Reproducing Individuals per population = 50 (USFWS, 2022). Number of populations and individuals needed for each plant species to meet the interim stage based on population and life history characteristics. Number of Populations = 3. Reproducing Individuals per population = 300 (USFWS, 2022). Number of population and individuals of each plant species needed for downlisting based on population and life history characteristics. Number of Populations = 5. Reproducing Individuals per population = 500 (USFWS, 2022).

Recovery Priority Number: 5

Delisting Criteria:

Number of populations and individuals of each plant species needed for delisting based on population and life history characteristics. Number of Populations = 10. Reproducing Individuals per population = 500 (USFWS, 2022).

Recovery Actions:

- Remove feral pigs from areas where *C. expansa* populations exist and prevent reinvasion through the use of exclosures.
- Control nonnative plants through physical, mechanical, and biological control methods, as well as herbicides when necessary.
- Conduct research into potential biocontrol species.
- Conduct field surveys in for additional populations in suitable *C. expansa* habitat.
- Reintroduce individuals into suitable habitat within historic range that is being managed for known threats to this species.
- Propagate and maintain genetic stock.

Conservation Measures and Best Management Practices:

- Current Management Actions: • Surveys and monitoring—No surveys have been conducted for this species since 2016 (Bustamente and Oppenheimer 2020, pers. comm.). • Ungulate control—Occurrences of *Calamagrostis expansa* within the Kahakuloa section of the West Maui NAR, Waikamoi PR, Hanawā NAR, and Haleakalā NP are provided protection by ungulate exclosures; however, the occurrence at Upper Waiākea on the island of Hawai‘i is not fenced. • Ecosystem-altering invasive nonnative plant control—Nonnative plant control efforts at Waikamoi PR, Hanawā NAR, and Haleakalā NP may benefit occurrences of *C. expansa* (TNC 2014, pp. 16–18; State of Hawai‘i 1989, pp. 26–28; Haleakalā NP 2018, 7 pp.). • Captive propagation for genetic storage and reintroduction— o Lyon Arboretum Seed Conservation Laboratory reported one seed accession in 2013 (87 seeds) representing an individual from Kawaipapa, and two seed accessions in 2013 (14,138 seeds) and in 2017 (968 seeds) representing individuals from Honokōhau in the Honokōwai section of the West Maui NARPu‘u Kukui population (Lyon Arboretum 2020). o The Olinda Rare Plant Facility (ORPF) reported three plants in storage representing one founder from Honokōhau in

the Honokōwai section of the West Maui NAR-Pu'u Kukui population (ORPF 2019). o Haleakalā NP reported 800 seeds in storage from the Kūhiwa population (Haleakalā NP 2019). • Population biology research—The results of a germination test indicated 26 percent viability initially with seeds germinating for a year after sowing (Lyon Arboretum 2020). (USFWS, 2021b).

References

USFWS 2014. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Calamagrostis expansa* (Maui reedgrass), Pacific Region (Region 1), 15 p. U.S. Fish and Wildlife Service. 2021. Draft recovery plan for 50 Hawaiian archipelago species. Portland, Oregon. xvi + 159 pp. USFWS. 2021b. *Calamagrostis expansa* (Maui reedgrass). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 22 pp. USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

USFWS 2014. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Calamagrostis expansa* (Maui reedgrass), Pacific Region (Region 1), 15 p. USFWS. 2021b. *Calamagrostis expansa* (Maui reedgrass). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 22 pp. USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

USFWS 2014. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Calamagrostis expansa* (Maui reedgrass), Pacific Region (Region 1), 15 p. U.S. Fish and Wildlife Service. 2021. Draft recovery plan for 50 Hawaiian archipelago species. Portland, Oregon. xvi + 159 pp. USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

USFWS. 2014. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Calamagrostis expansa* (Maui reedgrass), Pacific Region (Region 1), 15 p.

USFWS 2014. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Calamagrostis expansa* (Maui reedgrass), Pacific Region (Region 1), 15 p.

U.S. Fish and Wildlife Service. 2021. Draft recovery plan for 50 Hawaiian archipelago species. Portland, Oregon. xvi + 159 pp.

USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

USFWS. 2021b. *Calamagrostis expansa* (Maui reedgrass). 5-Year Review Summary and Evaluation

SPECIES ACCOUNT: *Calochortus tiburonensis* (Tiburon mariposa lily)

Species Taxonomic and Listing Information

Listing Status: Threatened; 3/6/1995; Pacific Southwest (R8)

Physical Description

A member of the lily family (Liliaceae) with a single persistent, basal, linear-oblong leaf 30 to 60 centimeters (1 to 2 feet) long. The flowering stem, about 50 centimeters (20 inches) tall, is usually branched and bears erect flowers in two's or three's at the ends of the branches. The three petals and three sepals (individual members of the outermost whorl or set of flower parts) are light yellow-green with reddish or purplish-brown markings. The capsule (dry fruit, generally with many seeds) is triangular in cross-section, and about 4 centimeters (2 inches) long (Hill 1973). The long slender hairs on the upper surface and margins of the petals and the lack of wings on the capsule distinguish *Calochortus tiburonensis* from the other two *Calochortus* species that are also found on the Tiburon Peninsula (Oakland star tulip [*Calochortus bellatus*] and yellow mariposa lily [*Calochortus luteus*]) (Hickman 1993). (USFWS, 1998)

Taxonomy

Robert West discovered *Calochortus tiburonensis* (Tiburon mariposa lily) in 1971 on Ring Mountain on the Tiburon Peninsula in Main County, California. Albert Hill collected the type specimen (a specimen or series of specimens chosen when the taxon is described and considered representative of the species, subspecies, or variety) on Ring Mountain the following year, and published the description in 1973 (Hill 1973). (USFWS, 1998)

Historical Range

See current range.

Current Range

Only known from the open, rocky, serpentine-derived soils of the serpentine bunchgrass community at Ring Mountain Preserve on the Tiburon Peninsula in southern Marin County, California. (USFWS, 2019)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexually, vegetative (USFWS, 2011)

Lifespan

Adult: Bulbs are thought to live 10 years or more. (USFWS, 2011)

Dependency on Other Individuals or Species

Adult: *Bombus californicus*. (USFWS, 2011)

Breeding Season

Adult: Flowers bloom between May and late June (LSA Associates, Inc. 2007). (USFWS, 2011)

Key Resources Needed for Breeding

Adult: Rainy season (USFWS, 1998)

Other Reproductive Information

Adult: The discovery of several Tiburon mariposa lily individuals with various mutations (i.e., petals missing hairs, lack of pigmentation, four petals and sepals instead of three, seven stamens instead of six) within the same small colony suggested these isolated colonies may be experiencing inbreeding or a loss of genetic diversity, and prompted the pollination experiments described here (pp. 12, 15, Photos 2 and 3). For the first year of the pollination study, a total of 30 plants were selected from a small, isolated colony and separated into one of three treatment groups to determine whether the species was experiencing insufficient pollen receipt that result in lower seed set. The first group received natural levels of pollination ("open pollination"), the second group received supplemental pollen from donors within the same small colony, and the third group received supplemental pollen from donor plants from the largest, most dense colony located 0.62 kilometers (0.39 miles) away (Swope 2013, p. 2). Results show individuals that receive supplemental pollen from donors within the same colony set seed >3 times more on average compared to plants that received open pollination, suggesting individuals are currently not receiving sufficient amounts of pollen (USFWS, 2022).

Reproduction Narrative

Adult: *Calochortus tiburonensis* is a bulbous perennial. Bulbs are thought to live 10 years or more. Depending on climatic factors, the flowers bloom between May and late June (LSA Associates, Inc. 2007). Reproductive adults typically bear two to three flowers, but larger individuals may produce as many as eight. Although self-pollination is possible with human intervention, protandry (male reproductive parts mature before female parts) likely limits self-pollination under natural conditions (P. Fiedler, personal communication 1996). The flowers are thought to be pollinated by bumble bees (*Bombus californicus*). The number of seeds per capsule averaged approximately 40 and ranged from 6 to 99. Seeds germinate at the onset of the rainy season. (USFW, 1998). *Calochortus tiburonensis* is known to produce bulbils (secondary bulbs), and may be capable of vegetative reproduction through bulbifery (the production of new propagules from bulbils). However, the extent to which *C. tiburonensis* vegetatively reproduces through bulbifery is unknown. Although the bulbs are thought to live 10 years or more, it is believed they do not reproduce sexually until about 5 years of age. (USFWS, 2011)

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Barrens, Grassland/ herbaceous (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: A serpentine grassland; open, rocky slopes. (NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Calochortus tiburonensis is an edaphic endemic (restricted to specific soil conditions) and are restricted to elevations between 400 to 600 feet. (USFWS, 2011)

Spatial Arrangements of the Population

Adult: Colonial (USFWS, 1998)

Environmental Specificity

Adult: Very Narrow (USFWS, 1998)

Habitat Narrative

Adult: Calochortus tiburonensis is an edaphic endemic (restricted to specific soil conditions), growing on open, rocky, serpentine slopes within the serpentine bunchgrass community on Ring Mountain Preserve in Marin County, between 120 and 180 meters (400 and 600 feet) elevation. (USFW, 2011). The single population of Calochortus tiburonensis is distributed in three major colonies (California Natural Diversity Data Base 1996) separated by 0.2 to 0.4 kilometer (0.125 to 0.25 mile) (P. Fiedler, pers. comm.', 1996). (USFWS, 1998)

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Stable. Recent decline (USFWS, 2022)

Number of Populations:

1 (USFWS, 2019)

Population Size:

~ 40,000 (USFWS, 2019).

Population Narrative:

The species has been known to occur only in the open, rocky, serpentine-derived soils at the Ring Mountain Preserve on the Tiburon Peninsula in southern Marin County, California. The population is divided into nine colonies that inhabit areas that range in size from 0.1 hectare (0.25 acre) to 13 hectares (32 acres). The density of plants within each of these nine areas is variable (LSA Associates, Inc. 2008; Service 2011b). The Ring Mountain Preserve is currently owned and managed by Marin County Parks and Open Space. It is implementing the approved 2007 Ring Mountain Preserve Sensitive Resources Monitoring and Enhancement Strategy (LSA Associates, Inc. 2007), which includes the management of nonnative plants and monitoring of permanent plots established within each of the nine Tiburon mariposa lily colonies located on the preserve (LSA Associates, Inc. 2007; Service 2011b). The status of the Tiburon mariposa lily has not changed substantially since it was listed in 1995 and the population has remained relatively stable (Service 2011b; Swope, Mills College, pers. comm. 2018). (USFWS, 2019). Different protocols have been used to monitor the population of Tiburon mariposa lily at the

Preserve, and therefore, the different data sets cannot be compared directly. The final listing rule described an estimated population size of 40,000 individuals in 1991 (Serpa pers. comm. 1992 in Service 1995, p. 6673) and the 2011 5-year review provides four years of monitoring data (2007–2008 and 2010–2011) from what was originally 25 plots (only 24 have been monitored after 2007), but only the number of plants within the plot was recorded and not an overall estimated population size (Service 2011, pp. 4–5; Marin County 2021a, p. 2). Monitoring has continued within those same plots, with a modification to the monitoring protocol in 2011 to collect data on a larger portion of life stages and an additional modification in 2015 to help analyze both short- and long-term trends for certain variables (Marin County 2021a, pp. 4, 28). Data collected from 2007 to 2020 within the established plots is summarized in Table 1. It is hard to determine what the species' population trend is with such large fluctuations in numbers from year to year; however, it appears the population has remained relatively stable or has experienced a recent decline (Service 2011, p. 10; Swope pers. comm. 2018; Marin County 2021a, pp. 6–7). Monitoring data still needs to undergo statistical analysis and a preliminary trend analysis suggests specialized software may be needed to better understand population trends (USFWS, 2022).

Threats and Stressors

Stressor: Habitat degradation (USFW, 2011)

Exposure:

Response:

Consequence:

Narrative: Even though this species is protected with a fence, it is susceptible to random events either natural or human due to the fact there is only one known occurrence. The preserve it inhabits is located very near a residential community. Random events such as fire, disease outbreak, landslides, or vandalism could have catastrophic effects on this species. This species is also threatened by potential overuse of the preserve due to its proximity to residential communities, and specifically by, bicycling, motorbikes, and pedestrians (USFWS, 2011).

Stressor: Restricted range (USFW, 2011)

Exposure:

Response:

Consequence:

Narrative: Because *Calochortus tiburonensis* exists as a single population with a highly restricted range it is susceptible to stochastic events such as prolonged drought, disease, landslide, or other infrequent and unforeseen causes of extinction. However, because *C. tiburonensis* has only been known from Ring Mountain Preserve, is likely naturally rare, and is a perennial plant species that does not appear to experience drastic fluctuations in population numbers, the threat of loss of genetic variability that is often associated with rare and highly restricted species does appear to represent a significant threat at this time. (USFW, 2011)

Stressor: Non-native invasive species (USFW, 2011)

Exposure:

Response:

Consequence:

Narrative: Competition from non-native invasive plant species was cited as a serious threat at the time of listing and poses one of the greatest threats to *Calochortus tiburonensis* today. The

Marin County Open Space District has been working to eradicate or control non-native invasive species from Ring Mountain Preserve for several years. (USFW, 2011)

Stressor: Predation (USFW, 2011)

Exposure:

Response:

Consequence:

Narrative: Mammalian herbivory, by mule deer (*Odocoileus hemionus*) and black-tailed jackrabbits (*Lepus californicus*), represents a minor threat to *Calochortus tiburonensis*. According to Serpa (1991), after four years of gathering data, herbivory on buds, flowers, and fruits does not appear to have a significant effect on reproduction; overall, 4.6 percent of the flowering structures were damaged by vertebrates in 1990, one percent in 1989, and 5.1 percent in 1988. (USFW, 2011)

Recovery

Reclassification Criteria:

Not applicable.

Recovery Priority Number: 17

Delisting Criteria:

A/1: One population (comprised of nine colonies) of Tiburon mariposa lily at Ring Mountain Preserve is fully protected and managed with the primary intention of preserving the population/colonies in perpetuity. Each protected area includes occupied habitat with adjacent unoccupied habitat and a 150-meter (500-foot) buffer, where possible. If additional individuals, colonies, or populations are discovered outside of the Ring Mountain Preserve, they are secured through voluntary land acquisition, conservation easements, or other means. (USFWS, 2019)

A/2: Management plans, approved by the Service, are developed and implemented for the population at Ring Mountain Preserve and any other location(s) where the species may be discovered (see A/1). Management plans include survival of the species as an objective and include any adjacent occupied or unoccupied habitat identified as essential to continued survival. The plan also includes provisions for annual standardized monitoring of each colony to determine demographic trends and strategies to control nonnative, invasive plant species. Adequate funding must be dedicated in order to implement the management plan in perpetuity. (USFWS, 2019)

E/1 As described in A/2, standardized colony monitoring at the Ring Mountain Preserve and any other location(s) where the species may be discovered (see A/1) shows stable or increasing trends over a period of 20 years that includes two normal precipitation cycles (or longer if suggested by the results of demographic monitoring). If monitoring shows any colony is declining, determine the cause of decline and reverse the trend. Because the species is a perennial, monitoring should include flowering, vegetative, and dormant individuals. (USFWS, 2019)

E/2: All protected colonies described in A/1 contain at least 1,000 individuals in order to maintain adaptive potential over the long-term, attract sufficient pollinators, and maintain

stable or increasing populations. Each colony contains reproductive, self-regenerating adults to produce a mixture of reproductive stages sufficient to ensure self-perpetuation. (USFWS, 2019)

E/3: Seeds from each population stored in at least two Center for Plant Conservation certified facilities and reliable seed germination and propagation techniques are understood. (USFWS, 2019)

Recovery Actions:

- Because the species is known only from Ring Mountain, protection and management of the species at Ring Mountain is of highest priority. This protection will involve working with the Main County Open Space District to ensure the long-term survival of the species by protecting each subpopulation, as well as a 150-meter (500-foot) buffer around each subpopulation, where possible, to reduce external influences and allow expansion of subpopulations. If plants (or additional populations) are discovered on private lands that are not part of the Ring Mountain Preserve, they should be secured through land acquisition, conservation easements, or other means. (USFWS, 1998)
- Unoccupied habitat that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. A management plan emphasizing *Calochortus tiburonensis* and other special status species at Ring Mountain must be developed and implemented. The plan ought to include provisions for standardized monitoring of each *Calochortus tiburonensis* subpopulation every 3 years. Because the species is a perennial, monitoring should include both flowering and vegetative individuals. The management plan should also include strategies to minimize known threats as well as to identify new threats as they may appear. Potential threats include invasion by non-natives, grazing by deer, and trash dumping. (USFWS, 1998)
- If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because the largest remaining natural population of *Calochortus tiburonensis* occurs on public land adjacent to human population centers, any management plan developed for Ring Mountain should include an educational outreach program. Protection of serpentine habitat at Ring Mountain Preserve may also benefit Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) and Main dwarf-flax (*Hesperolinon congestum*). (USFWS, 1998)
- Another high priority in conservation efforts for *Calochortus tiburonensis* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Such collections guard against extinction of the species from chance catastrophic events and provide potential material for enhancement efforts in existing populations and/or introductions to new sites. In the case of a species such as *Calochortus tiburonensis* that has never been known from other locations, introduction to new sites would generally be discouraged. Care should be taken to ensure that seed collection does not adversely affect the population. The best strategy would be to collect on a very small scale (less than 5 percent of the seed crop) and/or only in years with exceptional seed production. (USFWS, 1998)
- Research should be conducted into appropriate management strategies. For example, research into whether management techniques such as grazing, mowing, or burning may increase recruitment by removing thatch or otherwise stimulating reproduction would be valuable as would further research on demography to identify limiting life history stages, pollination, and habitat requirements of the species. Sloop (as cited in California Department of Fish and Game 1997b) feels that *Calochortus tiburonensis* is highly dependent on bumble bees for pollination. Further research to test this hypothesis would

- elucidate whether managers ought to consider threats to the bees to be threats to *Calochortus tiburonensis* as well. Development of germination and propagation techniques for *Calochortus tiburonensis* is also necessary. Because it occurs only at Ring Mountain, *Calochortus tiburonensis* should not be considered for delisting. Its status could be reevaluated in the unlikely event that several new populations are discovered at locations other than Ring Mountain. (USFWS, 1998)
- Continue annual population monitoring and non-native invasive plant control efforts (USFW, 2011).
 - Post informative signs at Ring Mountain Preserve entrances that describe the effects of off-trail use on rare plants (USFWS, 2011).
 - Determine if it is biologically feasible to store bulbs or seeds to reduce the threat of stochastic events (USFWS, 2011).

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS:** Here we propose several recommendations which will aid in the recovery and conservation of the Tiburon mariposa lily. These recommendations have already been discussed in previous recovery documents (Service 2011, p. 10; Service 2019, p. 48) and remain valid. 1. Continue annual monitoring and non-native invasive plant control efforts. Data collected from monitoring efforts should be statistically analyzed to determine population trends. If specialized software is needed to better understand trends, then that software should be identified and utilized to analyze the data. 2. Continue efforts to minimize off-trail use within the Preserve. Continue to educate visitors about the Preserve's sensitive resources and the effects off-trail use has on rare plants. 3. Store seeds in at least two Center for Plant Conservation certified facilities. Unless storage techniques and/or research show otherwise, replenish seed stock every 10 years to ensure seed viability. Research germination and propagation techniques. 4. Conduct genetic analyses on existing collected plant tissue to determine whether a genetic bottleneck is occurring within any colonies (USFWS, 2022).

References

USFWS. 2019. Amendment 1. Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area. U.S. Fish and Wildlife Service, Sacramento, California. 71 pp. September 26, 2019.

USFWS. 1998. Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area. U.S. Fish and Wildlife Service, Portland, Oregon. 330+ pp.

NatureServe. 2015. NatureServe Central Databases. FESTF received dataset on 08_11_2015. Arlington, Virginia, U.S.A

USFWS. 2011. *Calochortus tiburonensis* (Tiburon mariposa lily)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California

U.S. Fish and Wildlife Service. 1998. Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area. Portland, Oregon. 330+ pp. USFWS. 2022. Tiburon mariposa-lily (*Calochortus tiburonensis*) 5-Year Review: Summary and Evaluation. USFWS. Sacramento Fish and Wildlife Office Sacramento, California. 10 pp.

USFWS. 2019. Amendment 1. Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area. U.S. Fish and Wildlife Service, Sacramento, California. 71 pp. September 26, 2019. USFWS. 2022. Tiburon mariposa-lily (*Calochortus tiburonensis*) 5-Year Review: Summary and Evaluation. USFWS. Sacramento Fish and Wildlife Office Sacramento, California. 10 pp.

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. 13 pp. September 8, 2011. https://ecos.fws.gov/docs/five_year_review/doc3899.pdf

USFWS. 1998. Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area. U.S. Fish and Wildlife Service, Portland, Oregon. 330+ pp. https://ecos.fws.gov/docs/recovery_plan/980930c_v2.pdf

USFWS. 2022. Tiburon mariposa-lily (*Calochortus tiburonensis*) 5-Year Review: Summary and Evaluation. USFWS. Sacramento Fish and Wildlife Office Sacramento, California. 10 pp.

SPECIES ACCOUNT: *Carex albida* (White sedge)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/22/1997; Pacific Southwest (R8) (USFWS, 2015)

Physical Description

A perennial herb in the sedge family (Cyperaceae) with short fiber-covered rhizomes. The culms (stems) are triangular, 4 to 6 decimeters (1.3 to 2.0 feet) tall, erect, and longer than the leaves. Several traits distinguish *C. albida* from other closely related sedges. *Carex albida* has inflorescences with staminate (male) flowers above the pistillate (female) flowers, especially on the terminal inflorescence, lateral spikelets, and leaves that are shorter than the stems and 3 to 5 millimeters (0.1 to 0.2 inch) wide. Some individuals of *C. lemmonii* (Lemmon's sedge), which has not been documented in Sonoma County, resemble *C. albida*, but differ in perigynia and fruit size, and in other respects. (USFWS, 2009)

Taxonomy

Zika and Wilson (2012) found that characters of the perigynium, achene, inflorescence, and foliage do not separate *Carex albida* from *C. lemmonii* and that *C. albida* should be considered a synonym of the older name, *C. lemmonii*. (NatureServe, 2015)

Historical Range

See current range/distribution.

Current Range

Known only from a 10 square km area in Sonoma County, California. (NatureServe, 2015).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproduction Narrative

Adult: Not available

Habitat Type

Adult: Marshes and sphagnum bogs. (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Bog/fen, herbaceous wetland (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Acidic wetlands (USFWS, 2009)

Geographic or Habitat Restraints or Barriers

Adult: Restricted to freshwater wetlands with acidic, sandy/peaty fens, perennial wetlands, hillside seeps, and elevations between 45 and 60 m (USFWS, 2009)

Spatial Arrangements of the Population

Adult: Colonies (USFWS, 2009)

Environmental Specificity

Adult: Narrow/specialist

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2009)

Site Fidelity

Adult: High (inferred from USFWS, 2009)

Habitat Narrative

Adult: The only extant occurrence of *Carex albida* is found in perennial freshwater wetlands and hillside seeps, between 45 and 60 meters in elevations. These marshes have acidic sandy/peaty fens and supports mixed native willow riparian, oak woodland, grasslands, perennial freshwater marsh containing seeps and other diverse wetland features such as two quaking fens. Plant surveys in 2008 documented six colonies or patches. The species continues to be known from only one extant occurrence in the world in patches totaling no more than 5 acres (USFWS, 2009)

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Decreasing (USFWS, 2009)

Species Trends:

Decreasing (NatureServe, 2015)

Number of Populations:

1 extant occurrence (USFWS, 2009)

Population Size:

~300 (USFWS, 2009)

Population Narrative:

3 historically known occurrences were extirpated by wetland drainage, channelization of a stream, and by the disposal of cannery waste (CNPS 2001). At the time of listing *Carex albida* was known from a single extant occurrence with approximately 1,000 individuals. Current, *Carex albida* continues to be known from only occurrence in Sonoma County with approximately 300 reproductive stems.

Threats and Stressors

Stressor: Drought

Exposure:

Response:

Consequence:

Narrative: Factors cited to contributing to the low count were the driest spring on record, low temperatures during spring 2008, which could have reduced culm formation and flowering, and also the density and height of nonnative grasses that made it difficult to detect *C. albida* (Warner, 2008). (USFWS, 2009)

Stressor: Low temperatures

Exposure:

Response:

Consequence:

Narrative: Factors cited to contributing to the low count were the driest spring on record, low temperatures during spring 2008, which could have reduced culm formation and flowering, and also the density and height of nonnative grasses that made it difficult to detect *C. albida* (Warner, 2008). (USFWS, 2009)

Stressor: Well installations

Exposure:

Response:

Consequence:

Narrative: The marsh had become drier by the time of listing because the addition of wells and other construction had altered the marsh ecology (Guggolz, in litt. 1993). Drying of wetlands would not only directly impact the species but would encourage the spread of blackberries, which have become dominant in other parts of the marsh that have been drained (DFG 1993; Guggolz, in litt. 1993; CNDDDB 1996).

Stressor: Loss of habitat

Exposure:

Response:

Consequence:

Narrative: The threat of direct loss of historical habitat, particularly in the upper northern marsh continues with the incremental addition of new rural residences, driveways, and new agricultural operations (e.g., vineyards). Indirect effects of the impervious or bare surfaces from residential and agricultural land uses, respectively, accelerate runoff, increases nutrient loading, erosion, and sedimentation in the marsh and result in changes in soil pH and nutrients, in an otherwise acidic nutrient poor soil type. (USFWS, 2009)

Stressor: Water treatment facility

Exposure:

Response:

Consequence:

Narrative: Impacts cited in the 1997 listing from the water treatment facility located approximately 300 meters downstream of the northern marsh included the potential application

of recycled treated water on potentially suitable, but unoccupied habitat downstream, but within the historical range of *Carex albida* through modification of surface hydrology (Environmental Science Associates 1993). (USFWS, 2009)

Stressor: Highway maintenance and construction

Exposure:

Response:

Consequence:

Narrative: The State highway is located downstream and within 46 meters of the nearest colony of *Carex albida*. County road maintenance crews periodically trim back the willows and other riparian species from the road edges, which leave openings that facilitate invasion of weedy species. If highways were ever widened, it would involve encroachment into the wetland area which would impact the hydrology, possibly resulting in the direct loss of occupied habitat, and facilitate the invasion of nonnative vegetation. (USFWS, 2009)

Stressor: Surrounding land practices

Exposure:

Response:

Consequence:

Narrative: *C. albida* continues to be vulnerable to threats from surrounding land use practices which have potential to adversely alter surface and subsurface hydrology, and from competition from invasive species, and potential disturbance from repair or alteration of a nearby State highway. (USFWS, 2009)

Stressor: Invasive plants

Exposure:

Response:

Consequence:

Narrative: Invasive, nonnative blackberries and grasses as well as native willow have encroached into the habitat of these species and appear to be increasing in density in recent years (Cooley, pers. Comm. 2008). (USFWS, 2009)

Stressor: Foot traffic

Exposure:

Response:

Consequence:

Narrative: Trampling from increased human foot traffic for scientific, educational, and possible recreational purposes poses a threat. *Carex albidia* blends with surrounding vegetation and can be difficult to identify. (USFWS, 2009)

Stressor: Climate change

Exposure:

Response:

Consequence:

Narrative: A trend of warming of western North America is expected to decrease snowpack, hasten spring runoff, and reduce summer stream flows (IPCC 2007). Increased summer heat may increase the frequency and intensity of wildfires (IPCC 2007). Rapid climate change may place native species with long generation times at a disadvantage because they cannot quickly move

into newly suitable habitat. (USFWS, 2009)

Stressor: Random events

Exposure:

Response:

Consequence:

Narrative: The habitat is extremely limited and isolated through their ranges due to the natural rarity of their habitat. (USFWS, 2009)

Recovery

Reclassification Criteria:

Reclassification criteria is not available.

Delisting Criteria:

Delisting criteria is not available.

Recovery Actions:

- No recovery plans are available for this species.
- Increase the size of existing protected habitat through conservation easements or, preferably, fee-title acquisition. Manage these properties to protect and enhance the habitat and occurrences of *Carex albida*.
- Prepare and publish a draft recovery plan and ultimately finalize the recovery plan.
- Work with willing landowners in or near historical occurrences to develop access agreements to conduct surveys, monitoring, and habitat enhancements, and provide them assistance to minimize their indirect land use impacts on occupied habitat.
- Monitor and continue adaptive management of existing protected areas to control invasive vegetation, address excess sediment and nutrients in the marshes, and encourage growth of listed species and co-occurring rare plant taxa within their historical occurrences.
- Continue to maintain a viable, protected seed collection for *Carex albida*. Ensure sufficient seeds exist, preferably in more than one repository, to maintain genetic heterogeneity. For long term preservation of genetic diversity consideration should be given to having a clone bank as a supplement or alternative to seed storage. A clone bank would be a low-maintenance partial shade garden from either seed or bulb scales of the original occurrence.

References

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

U.S. Fish and Wildlife Service. 2009. *Carex albida* (White sedge) *Lilium pardalinum* ssp. *pitkinense* (Pitkin marsh lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Accessed 06/08/2016

SPECIES ACCOUNT: *Carex lutea* (Golden sedge)

Species Taxonomic and Listing Information

Listing Status: Endangered; 2/22/2002; Southeast Region (R4)

Physical Description

A perennial member of the sedge family (Cyperaceae). Fertile culms (stems) may reach 39 inches (in) (1 meter; m) or more in height. The yellowish green leaves are grasslike, with those of the culm mostly basal and up to 11 in (28 centimeters; cm) in length, while those of the vegetative shoots reach a length of 25.6 in (65 cm). Fertile culms produce two to four flowering spikes (compact flower clusters), with the terminal spike being male and the one to three (usually two) lateral spikes being female. Lateral spikes are subtended by leaflike bracts (a much-reduced leaf). The male spike is about 0.8 – 1.6 in (2 - 4 cm) long, 0.06 – 0.1 in (1.5 - 2.5 millimeters; mm) wide, with a peduncle (stalk) about 0.4 – 2.4 in (1 - 6 cm) long. Female spikes are round to elliptic, about 0.4 – 0.6 in (1 - 1.5 cm) long and 0.4 in (1 cm) wide. The upper female spike is sessile (not stalked; sitting), while lower female spikes, if present, have peduncles typically 0.2 – 1.8 in (0.5 - 4.5 cm) long. When two to three female spikes are present, each is separated from the next along the culm by 1.8 – 7.1 in (4.5 to 18 cm). The inflated perigynia (sac which encloses the seed) are bright yellow when seeds mature and about 0.16 – 0.20 in (4 to 5 mm) long. The perigynia are out-curved and spreading, with the lowermost in a spike strongly reflexed (turned downward) (LeBlond et al. 1994). (USFWS, 2014)

Taxonomy

Carex lutea was first collected by Richard LeBlond on April 11, 1990, in Pender County, North Carolina. It was collected in an immature state. From analysis of a mature specimen collected on May 22, 1991, it was determined that the taxon belonged to the genus *Carex*, section *Ceratocystis* (=Extensae), a circumboreal section not previously known from North Carolina. Sedges of the section *Ceratocystis* occur in temperate regions in North America, Europe, Asia, and Australia. In North America, they are primarily in the northern temperate region. *Carex lutea* is the southern-most species in the section in North America (Ball and Reznicek 2003). (USFWS, 2014)

Historical Range

Endemic to the outer coastal plain of North Carolina (USFWS, 2014).

Current Range

Known occurrences are in Pender and Onslow Counties, NC. (USFWS, 2015)

Critical Habitat Designated

Yes; 3/31/2011.

Legal Description

On March 1, 2011, the U.S. Fish and Wildlife Service (Service) designated critical habitat (effective March 31, 2011) for *Carex lutea* (Golden sedge) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes eight critical habitat units (CHUs), in North Carolina (76 FR 11086-11111). (USFWS, 2011)

Critical Habitat Designation

The critical habitat designation for *Carex lutea* includes eight CHUs (including 19 sub-units) in Onslow and Pender Counties, North Carolina. This species critical habitat encompasses approximately 202 acres (ac) (82 hectares (ha)). Brief descriptions and promulgated descriptions are provided below; maps are available in the Final Rule (76 FR 11086-11111). (USFWS, 2011)

Unit 1: Watkins Savanna, Pender County, North Carolina: Unit 1 consists of 3.8 ac (1.5 ha) and includes three subunits in Pender County, NC. Promulgated Unit 1 description: (i) Unit 1, subunits A, B, and C, for *Carex lutea* comprises 3.8 acres (ac) (1.5 hectares (ha)) of somewhat overgrown Pine Savanna habitat. Unit 1 is located approximately 5.1 miles (mi) (8.2 kilometers (km)) southeast of the intersection of NC 50 and NC 53, and all three subunits are on the north side of NC 50. (ii) Subunit 1A. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 732264, 99984; 732203, 99954; 732184, 100016; 732234, 100065; 732264, 99984. (iii) Subunit 1B. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 733143, 99288; 733053, 99268; 733055, 99291; 733065, 99309; 733055, 99320; 733048, 99344; 733053, 99364; 733090, 99377; 733140, 99370; 733143, 99288. (iv) Subunit 1C. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 732155, 99677; 732128, 99667; 732093, 99716; 732109, 99732; 732166, 99692; 732155, 99677. (USFWS, 2011)

Unit 2: Haws Run Mitigation Site, Onslow County, North Carolina: Unit 2 (EO 7) consists of 27.1 ac (11.0 ha) in Onslow County, NC. Promulgated Unit 2 description: (i) Unit 2 for *Carex lutea* comprises 27.1 ac (11.0 ha) of Pine Savanna. Unit 2 is located approximately 7.6 mi (12.2 km) southeast of the intersection of NC 50 and NC 53, on the south side of NC 50. (ii) Unit 2. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 735078, 96823; 735188, 96794; 735282, 96812; 735423, 96489; 735296, 96437; 735329, 96364; 735233, 96324; 735132, 96601; 735053, 96564; 734996, 96686; 735049, 96740; 735078, 96823. (USFWS, 2011)

Unit 3: Maple Hill School Road Savanna, Pender County, North Carolina: Unit 3 (EO 10) consists of 27.7 ac (11.2 ha) in Pender County, NC. Promulgated Unit 3 description: (i) Unit 3 for *Carex lutea* comprises 27.7 ac (11.2 ha) of Pine Savanna. Unit 3 is located approximately 3.7 mi (6.0 km) southeast of the intersection of NC 50 and NC 53, east of SR 1580 and north of NC 50. (ii) Unit 3. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 731509, 101826; 731333, 101675; 731094, 101706; 731187, 101962; 731239, 101964; 731253, 101975; 731264, 102030; 731435, 102129; 731509, 101826. (USFWS, 2011)

Unit 4: Southwest Ridge Savanna, Pender County, North Carolina: Unit 4 (EO 11) consists of 3.3 ac (1.3 ha) in two subunits in Pender County, NC. Promulgated Unit 4 description: (i) Unit 4, subunits A and B, for *Carex lutea* comprises 3.3 ac (1.3 ha) of maintained power line on the edge of Pine Savanna. Unit 4 is located approximately 9.1 mi (14.7 km) southwest of the intersection of NC 50 and NC 53. (ii) Subunit 4A. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 723852, 89908; 723720, 89734; 723688, 89761; 723756, 89851; 723820, 89935; 723852, 89908. (iii) Subunit 4B. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 724036, 90152; 723975, 90075; 723946, 90104; 724004, 90177; 724036, 90152. (USFWS, 2011)

Unit 5: Sandy Run Savannas, Onslow County, North Carolina: Unit 5 consists of 25.2 ac (10.2 ha) in Onslow County, NC, and is divided into five subunits. Promulgated Unit 5 description: (i) Unit 5, subunits A, B, C, D and E, for *Carex lutea* comprises 25.2 ac (10.2 ha) of power line right-of-way,

ecotone and Pine Savanna habitat. Unit 5 is located approximately 7.1 mi (11.4 km) southeast of the intersection of NC 50 and NC 53. Subunit A is located in a power line corridor east of NC 50, and subunits B, C, D, and E are west of NC 50. (ii) Subunit 5A. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 736771, 99308; 736625, 99178; 736587, 99216; 736737, 99350; 736771, 99308. (iii) Subunit 5B. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 735365, 98631; 735349, 98617; 735348, 98651; 735379, 98706; 735452, 98755; 735543, 98767; 735619, 98723; 735502, 98683; 735365, 98631. (iv) Subunit 5C. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 735711, 98665; 735692, 98664; 735692, 98680; 735687, 98688; 735664, 98688; 735650, 98706; 735666, 98715; 735673, 98706; 735697, 98704; 735711, 98689; 735711, 98670; 735711, 98665. Subunit 5D. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 735817, 98757; 735769, 98743; 735761, 98762; 735812, 98776; 735817, 98757; and, 735756, 98767; 735745, 98774; 735722, 98827; 735720, 98863; 735761, 98907; 735787, 98905; 735795, 98859; 735810, 98821; 735864, 98838; 735899, 98854; 735928, 98871; 735958, 98894; 735983, 98894; 735990, 98820; 735850, 98795; 735756, 98767. (vi) Subunit 5E. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 736501, 99084; 736411, 99048; 736382, 99079; 736375, 99137; 736318, 99202; 736292, 99251; 736374, 99312; 736476, 99354; 736532, 99252; 736610, 99159; 736559, 99115; 736501, 99084. (USFWS, 2011)

Unit 6: The Neck Savanna, Pender County, North Carolina: Unit 6 consists of 4.4 ac (1.8 ha) in Pender County, NC, and is divided into three subunits. Promulgated Unit 6 description: (i) Unit 6, subunits A, B, and C, for *Carex lutea* comprises 4.4 ac (1.8 ha) of power line right-of-way, Pine Savanna habitat. Unit 6 is located approximately 5.3 mi (8.5 km) southeast of the intersection of NC 50 and NC 53. All three subunits are located south of NC 50. Subunits 6A and 6B are located in remnant Pine Savanna ecotones southeast of SR 1532, and Subunit 6C is located along a power line right-of-way adjacent to Williams Road. (ii) Subunit 6A. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 731077, 98383; 731055, 98378; 731023, 98410; 731008, 98465; 731036, 98516; 731078, 98542; 731132, 98546; 731132, 98531; 731117, 98465; 731114, 98417; 731112, 98391; 731077, 98383. (iii) Subunit 6B. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 731177, 97874; 731139, 97824; 731093, 97810; 731042, 97830; 731047, 97843; 731094, 97828; 731130, 97839; 731168, 97888; 731198, 97895; 731200, 97879; 731177, 97874. (iv) Subunit 6C. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 731691, 98462; 731678, 98456; 731668, 98491; 731680, 98496; 731691, 98462. (USFWS, 2011)

Unit 7: Shaken Creek Savanna, Pender County, North Carolina: Unit 7 consists of 57.7 ac (23.4 ha) in Pender County, NC, and is divided into three subunits. Promulgated Unit 7 description: (i) Unit 7, subunits A, B, and C, for *Carex lutea* comprises 57.7 ac (23.4 ha) of Pine Savanna habitat. Unit 7 is located approximately 8.6 mi (13.8 km) southeast of the intersection of NC 50 and NC 53. All three subunits are located west of NC 50. Subunit 7A is immediately south side of Flo Road and east of Alligator Lake Road. Subunit 7B is immediately south of Flo Road and west of Alligator Lake Road. Subunit 7C is immediately south of Flo Road and approximately 1,800 feet (549 meters) west of Alligator Lake Road. (ii) Subunit 7A. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 734066, 92945; 734015, 92941; 733993, 92959; 733995, 92973; 733987, 92987; 733976, 93018; 733972, 93074; 733967, 93130; 733970, 93156; 733983, 93185; 734006, 93222; 734060, 93204; 734057, 93140; 734080, 93088; 734114, 93044; 734096, 92963; 734066, 92945. (iii) Subunit 7B. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 733868, 92812; 733817, 92804; 733727, 92937; 733704, 93040; 733648,

93073; 733640, 93213; 733823, 93232; 733964, 93244; 733997, 93225; 733955, 93155; 733966, 93022; 733985, 92968; 733959, 92949; 733926, 92936; 733886, 92909; 733862, 92857; 733868, 92812. (iv) Subunit 7C. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 733556, 93081; 733560, 92976; 733522, 92933; 733449, 92943; 733393, 92985; 733351, 93010; 733327, 93048; 733280, 93055; 733217, 93035; 733165, 92990; 733106, 92968; 733059, 92992; 733030, 93034; 732976, 93056; 732902, 93101; 732883, 93132; 733202, 93163; 733318, 93178; 733549, 93206; 733556, 93081. (USFWS, 2011)

Unit 8: McLean Savanna, Pender County, North Carolina: Unit 8 consists of 52.6 ac (21.3 ha) and includes three subunits in Pender County, NC. Promulgated Unit 8 description: (i) Unit 8, subunits A, B, and C, for *Carex lutea* comprises 52.6 ac (21.3 ha) of Pine Savanna and ecotone habitat. Unit 8 is located approximately 16.4 mi (26.4 km) south of the intersection of NC 50 and NC 53 and approximately 2.1 mi (3.4 km) east of NC 210. (ii) Subunit 8A. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 722520, 77995; 722417, 77935; 722283, 78037; 722146, 78244; 722013, 78436; 722019, 78444; 722433, 78542; 722540, 78390; 722492, 78276; 722398, 78205; 722520, 77995. (iii) Subunit 8B. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 722780, 77840; 722846, 77820; 722907, 77802; 722903, 77787; 722842, 77806; 722774, 77825; 722780, 77840; 722780, 77840; 722779, 77841; 722780, 77840; 722780, 77840. (iv) Subunit 8C. Land bounded by the following UTM Zone 18, NAD 83 coordinates (E,N): 723268, 78269; 723209, 78309; 723166, 78305; 723179, 78361; 723313, 78465; 723446, 78537; 723408, 78370; 723395, 78307; 723335, 78264; 723268, 78269. (USFWS, 2011)

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 *Carex lutea* critical habitat consists of three components (76 FR 11086-11111) :

- (i) Moist to completely saturated loamy fine sands, fine sands, fine sandy loams, and loamy sands soils with a pH between 5.5 and 7.2;
- (ii) Open to relatively open canopy that allows full to partial sunlight to penetrate to the herbaceous layer between savannas and hardwood forests; and
- (iii) Areas of bare soil immediately adjacent (within 12 inches (30 centimeters)) to mature *Carex lutea* plants where seeds may fall and germinate or existing plants may expand in size.

Special Management Considerations or Protections

The major threats to the features in the areas identified as critical habitat for *Carex lutea* include: Habitat alteration; conversion of its limited habitat for residential, commercial, or industrial development; mining; drainage activities associated with silviculture and agriculture; suppression of fire; highway expansion; and herbicide use along utility and highway rights-of-way. Through our review of the existing data on *Carex lutea*, we conclude that these threats, which were also listed in the final listing rule (67 FR 3120, January 23, 2002), continue to impact this species and its essential physical and biological features. The destruction of habitat or conversion of habitat for residential, commercial, or industrial development can change the topography, soils, and general character of the site, making it uninhabitable for *Carex lutea*. These activities can remove the primary constituent element by removing soil (by grading) and changing *Carex lutea* habitat

to developed land, which is unsuitable for the species. Drainage activities associated with silviculture and agriculture may alter the hydrology, which can change the groundwater levels and the amount of moisture in the soil, creating conditions under which *Carex lutea* may not be able to survive. Further, removal of existing vegetation or the planting of trees for silviculture may change the existing conditions such that *Carex lutea* plants no longer receive optimal amounts of sunlight. The close proximity of roadways and power line corridors to populations of *Carex lutea* may affect the species. Herbicide treatment to maintain vegetation in rights-of-ways has the potential to kill non-target plant species such as *Carex lutea*. Highway expansion may change the local topography and affect water runoff making the site drier or wetter than is optimal for *Carex lutea*. Mining has been documented in close proximity to one *Carex lutea* population. Mining activities may alter many aspects of *Carex lutea* habitat. Heavy equipment can compact or remove the appropriate soils. The grading of areas adjacent to *Carex lutea* habitat can change the hydrology of those areas and make them more susceptible to invasion by nonnative plant species. Regular fire in areas where *Carex lutea* occurs helps to maintain the open savanna habitat that is conducive to *Carex lutea* growth. Fire reduces competition and allows seeds to germinate in open, bare soil areas. Fire suppression in areas where *Carex lutea* occurs may result in the growth of shrubs and trees that will eventually shade out herbaceous species such as *Carex lutea*. Fire suppression also allows the invasion of nonindigenous plants and animals that are not fireadapted. All of these activities may in turn lead to the disruption of the growth and reproduction of *Carex lutea*. In summary, we find that the areas we are designating as critical habitat contain the features essential to the conservation of *Carex lutea*, and that these features may require special management considerations or protection. Special management considerations or protection may be required to eliminate, or reduce to negligible level, the threats affecting each unit or subunit and to preserve and maintain the essential features that the critical habitat units and subunits provide to *Carex lutea*. Additional discussions of threats facing individual sites are provided in the individual unit and subunit descriptions. (USFWS, 2011)

Life History**Food/Nutrient Resources****Reproductive Strategy**

Adult: Sexual, asexual (USFWS, 2014)

Lifespan

Adult: > 2 years (USFWS, 2014)

Breeding Season

Adult: April - May (USFWS, 2014)

Key Resources Needed for Breeding

Adult: Wind (USFWS, 2014)

Reproduction Narrative

Adult: Pollination probably occurs via abiotic factors (EPA, 2016). *Carex lutea* is a perennial (plant with a life span greater than two years). Flowering occurs from mid April to early May. Because ample mature seed production has been observed, the Service can confidently surmise

that *Carex lutea* reproduces both sexually, involving gravity and wind dispersed pollen, as well as vegetatively (L. Bruederle, University of Colorado Denver, pers. comm. 2007). Survival rates and the nature of mortality of individual plants are unknown (USFWS, 2014).

Habitat Type

Adult: Palustrine (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Forested wetland, herbaceous wetland (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Soil pH 5.5 - 7.2; periodic fires (USFWS, 2015)

Spatial Arrangements of the Population

Adult: Clumped (USFWS, 2015)

Environmental Specificity

Adult: Very narrow to narrow (NatureServe, 2015)

Habitat Narrative

Adult: *Carex lutea* is found in very wet to saturated to periodically shallowly inundated soils. The largest populations are found in the wet to saturated ecotones of savannas and hardwood forests. At a few sites, the plants are most abundant in wet to saturated soils adjacent to drainage ditches, and in the saturated to shallowly inundated ditches themselves. While ditches are not natural habitat for the species, they serve as surrogate, but not high quality, habitat. The occurrence of *C. lutea* plants in ditches is likely due to the wetter soils of the ditches, and/or the washing of seeds into the ditches from adjacent microhabitat. *C. lutea* occasionally occurs in very wet soil in areas of savanna habitat characterized by an open to absent canopy, suggesting that its abundance in the savanna/wet hardwood ecotone is strongly influenced by hydrologic conditions as well as by edaphic and/or light conditions. Taggart and Long (2012) found that mean pH values for the topsoils within three *C. lutea* populations were strongly (4.7) to moderately (5.7) acidic. (USFWS, 2015)

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Seeds have been observed in ditches adjacent to colonies, indicating dispersal by precipitation sheet flow. Animals may also be seed dispersers; the perigynia beaks are minutely serrulate, perhaps an adaptation for attachment to fur (USFWS, 2014).

Population Information and Trends**Population Trends:**

Unknown (NatureServe, 2015)

Species Trends:

Stable (USFWS, 2015)

Number of Populations:

11 (USFWS, 2022)

Population Size:

1000 - 2500 individuals (NatureServe, 2015)

Population Narrative:

The long-term population trend is unknown. The Lanier quarry site has over 1000 clumps and the rest of the sites have a combined total of 100 clumps (NatureServe, 2015). Based on four years of monitoring data and great strides in the protection of *C. lutea* sites, the Service believes that the status of this species is currently stable. According to genetic analysis by Derieg et al. (2008, 2013), *Carex lutea* maintains the highest levels of genetic diversity observed in North American populations of section *Ceratocystis* taxa. It is extremely rare due to high habitat specificity and narrow range of distribution (USFWS, 2015). The North Carolina Natural Heritage Program (NCNHP) currently recognizes eight populations of *Carex lutea* (USFWS, 2014). Including the FL populations mentioned above, there are currently 11 extant populations and one population that may be extirpated (surveyors failed to find individuals when the population was last visited. Since the completion of the September 24, 2015, Five-Year Review, three new populations of *Carex lutea* have been discovered in Florida (FL) and one in South Carolina (SC). Since the last Five-Year Review, the ranks of one NC population improved and two NC populations declined. NC 15 changed from a poor (D) to fair (C) ranking, indicating the population is better than previously reported. Even though this population has improved, approximately 5% of this population was destroyed by a road improvement project in 2021 (Ed Corey, NC State Parks, pers. comm., January 19, 2022). Population NC 18 changed from a rank of excellent (A) to poor (C) indicating the population has declined, due to fire suppression and herbicide damage. Population 10 changed from a rank of poor? (C?) to "failed to find" (F) indicating that no plants were found during recent surveys of that site (NCNHP 2022). In 2021, three new populations were discovered in FL and one was discovered in SC. All four new populations occur on conservation lands (FNAI 2022, SCHTP 2022). Additional information about population rankings and these new populations is provided in Appendices A and B, respectively (USFWS, 2022).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: Habitat destruction, resulting from development, also threatens *C. lutea*, but to a lesser degree than the other factors listed above as many of the populations are in conservation ownership. Sites located within road and utility rights-of-way are threatened by herbicide use or mowing during critical growth periods. While the recovery plan listed timber operations such as harvesting, bedding and ditching as threats to the species, the Service knows that timber operations to varying degrees have occurred at all *C. lutea* sites at some point in the past. Observations in 2012 indicate that a large portion of land in the vicinity of this population has been converted into a blueberry farm. (USFWS, 2015)

Stressor: Invasive species (USFWS, 2015)

Exposure:**Response:****Consequence:**

Narrative: Cogon grass (*Imperata cylindrica*) was introduced to the United States in 1912 and is found in longleaf pine plant communities throughout the southeast. A population of cogon grass was found in Pender County in 2012 (Glen2012). Cogon grass is listed as a federal noxious weed by the U.S. Department of Agriculture and a state noxious weed by the NC Department of Agriculture and Consumer Services (NCDACS 2015). Given its growth habit and habitat preferences, *I. cylindrica* could displace native species such as *C. lutea*, however, it has not yet been observed at any of the known *C. lutea* sites (USFWS, 2015).

Stressor: Stochastic events (USFWS, 2015)

Exposure:**Response:****Consequence:**

Narrative: Small population sizes likely diminish the resiliency of *Carex lutea* occurrences to stochastic disturbances, and the lack of redundancy across the landscape leaves the species at greater risk of extinction due to potential extirpation of these vulnerable occurrences. Other threats to the species include extended drought that may be exacerbated by the installation of drainage ditches (USFWS, 2015).

Stressor: Fire suppression (USFWS, 2014)

Exposure:**Response:****Consequence:**

Narrative: *Carex lutea* is threatened by fire suppression and the ecological succession (competition and/or shading by woody species) associated with areas that are not burned as often as they were historically (USFWS 2014).

Recovery**Reclassification Criteria:**

1. There are 10 protected *C. lutea* sites in the wild that are distributed across the range of the species. [Note: Recovery sites will be considered permanently protected when they are placed under a conservation easement or other binding land agreement and a management agreement and are ranked as an A or B population by the NCNHP. See Appendix C of the Recovery Plan for additional information about the rank specifications for *C. lutea*.] (USFWS, 2014).
2. On each of the 10 *C. lutea* sites, for at least 5 years, any non-native plant species that have the potential to displace *C. lutea* are maintained at or below 10 percent of total number of species and at or below 10 percent cover (volume) (USFWS, 2014).
3. All 10 *C. lutea* sites demonstrate stable or increasing population trends for five consecutive years (USFWS, 2014).
4. Habitat management plans are actively being implemented for at least seven of the protected sites (USFWS, 2014).

5. A prescribed fire regime has been developed and is being conducted at all sites to mimic historical frequency and timing (the frequency will be determined through recovery actions in this plan) (USFWS, 2014).

Recovery Priority Number: 8

Delisting Criteria:

1. There are 15 protected sites in the wild that are distributed across the range of the species. [Note: Recovery sites will be considered permanently protected when they are placed under a conservation easement or other binding land agreement and a management agreement and are ranked as an A or B population by the NCNHP. See Appendix C of the Recovery Plan for additional information about the rank specifications for *C. lutea*.] (USFWS, 2014).
2. On each of the 15 *C. lutea* sites, for at least 5 years, any non-native plant species that have the potential to displace *C. lutea* are maintained at or below 10 percent of total number of species and at or below 10 percent cover (volume) (USFWS, 2014).
3. All 15 *C. lutea* sites demonstrate stable or increasing population trends for ten consecutive years (USFWS, 2014).
4. Habitat management plans are actively being implemented for all protected sites and are showing evidence that actions are proving effective for this plant (USFWS, 2014).
5. A prescribed fire regime is being conducted at all sites to mimic historical frequency and timing (which will be determined through recovery actions) (USFWS, 2014).

Recovery Actions:

- Protect *Carex lutea* sites/occurrences and adjacent buffer habitat around these sites: *Carex lutea* is a unique plant in the wet pine savannas of North Carolina. Due to threats, it is now known from a limited number of occurrences in Pender and Onslow Counties that need to be protected to ensure their survival. (USFWS, 2014)
- Increase and strengthen *Carex lutea* sites/occurrences: For this relatively recently described plant, there is much to learn about its biology (see actions under 6.0 for Research) and how it fits as a key piece in the wet pine savanna. As we complete population augmentations and other recovery actions, we will strengthen our largest *Carex lutea* occurrences. (USFWS, 2014)
- Management: Since this plant clearly occurs on limited islands of habitat within pine savanna that have unique habitat characteristics (higher pH, wet soils, limestone), we need to work to manage aspects like invasive plants to ensure *Carex lutea* can thrive. (USFWS, 2014)
- Surveys: Extensive surveys that have been conducted for *Carex lutea* have led to the discovery of a few new occurrences. Based on existing knowledge, we do not anticipate finding a lot of additional populations, but it should be a priority to survey any remaining patches of unique wet pine savanna habitat to ensure that we protect this endangered plant. Survey efforts should focus on identifying areas of suitable habitat where *Carex lutea* may occur with the goal of finding additional populations of this species. (USFWS, 2014)
- Monitoring: Range-wide, long-term monitoring is critical to understanding population trends and the overall health of individual sites and populations. (USFWS, 2014)

- Research: *Carex lutea* is relatively recently described and has a very restricted range. Consequently, little research has been conducted on this species. (USFWS, 2014)
- Education and Outreach: Education and outreach is important in order to inform the residents and land managers in the vicinity of *Carex lutea* sites about the significance of the species and why long term management of these sites, through prescribed burning and other measures, is necessary for their survival. (USFWS, 2014)
- Conduct surveys for additional populations, especially in shady areas where it was previously thought the species did not occur (USFWS, 2015)
- Protect as many populations as possible (USFWS, 2015).
- Develop site specific management and prescribed burn land managers to implement management plans (USFWS, 2015).
- Continue long term monitoring that was initiated by plans for each site and encourage the NCBG to assess population trends, reproductive success and threats (USFWS, 2015).
- Conduct additional research on general life history and biology of the species (USFWS, 2015).
- Conduct research to determine the effects of various timber operations on this species (USFWS, 2015).
- Develop and implement an education and outreach program to help partners and local landowners (USFWS, 2015).
- Identify potential sites for introducing new populations of the species (USFWS, 2015).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIVITIES The recommended actions listed in the 2015 Five-Year Review remain important to the conservation and recovery of *Carex lutea* and efforts to accomplish those actions should continue. The Service recommends initiating or continuing the following efforts that will contribute to the recovery of the species: • Conduct genetic analysis on the newly discovered populations to confirm they are *Carex lutea*. • Since the species has been found in two new states, consider updating/amending the Recovery Plan to make references to specific state agencies more general after genetic studies confirm these populations are definitely *Carex lutea*. • Conduct surveys for additional populations, especially in shady areas where it was previously thought the species did not occur, • Protect and manage as many populations as possible, • Determine status of known populations that have not been visited in recent years, • Develop site specific management and prescribed burn plans for NC 10, 11 and 18, • Check in with land managers annually to ensure that management plans are being implemented, • Continue long term monitoring that was initiated by the NC Botanical Garden and The Nature Conservancy to assess population trends, reproductive success and threats, • Conduct additional research on general life history and biology of the species, • Conduct research to determine the effects of various management and timber operations on this species, • Develop and implement an education and outreach program to help partners and local landowners, • Identify potential sites for introducing new populations of the species, • Make sure all populations are represented in the seed bank at the NC Botanical Garden (USFWS, 2022).

References

USFWS. 2015. Golden Sedge (*Carex lutea*), 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Kentucky Ecological Services Field Office. 17 pp. August 24, 2015.
https://ecos.fws.gov/docs/five_year_review/doc4595.pdf

USFWS. 2014. Recovery Plan for Golden Sedge (*Carex lutea*). U.S. Fish and Wildlife Service, Atlanta, Georgia. 48 pp.

USFWS. 2011. Designation of Critical Habitat for *Carex lutea* (Golden Sedge). Final Rule. U.S. Fish and Wildlife Service. 76 FR 11086-11111 (March 1, 2011).

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

USFWS. 2015. Golden Sedge (*Carex lutea*), 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Kentucky Ecological Services Field Office. 17 pp. August 24, 2015.

USFWS. 2015. Golden Sedge (*Carex lutea*), 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Kentucky Ecological Services Field Office. 17 pp. August 24, 2015.

USFWS. 2014. Recovery Plan for Golden Sedge (*Carex lutea*). U.S. Fish and Wildlife Service, Atlanta, Georgia. 48 pp. USFWS. 2022. Golden Sedge (*Carex lutea*) Status Review: Summary and Evaluation. Southeast Region. Raleigh Ecological Services Field Office Raleigh, North Carolina. 12 pp.

USFWS. 2022. Golden Sedge (*Carex lutea*) Status Review: Summary and Evaluation. Southeast Region. Raleigh Ecological Services Field Office Raleigh, North Carolina. 12 pp.

SPECIES ACCOUNT: *Carex specuicola* (Navajo sedge)

Species Taxonomic and Listing Information

Listing Status: Threatened; 06/07/1985; Southwest Region (R2)

Physical Description

Carex specuicola is a grass-like, slender perennial forb in the sedge family, Cyperaceae. Culms (stems) are 15 to 50 centimeters (cm) (6 to 20 inches [in]) long, lax (not upright), and longer (sometimes shorter) than the leaves. Many culms grow from a rhizome (underground stem), giving the plant a clumped form, often in extensive monospecific mats, with a persistent, dried leaf base. Each plant has male and female flowers, which are inconspicuous. Male flowers only occur on the terminal spike (end of culm), almost always below female flowers; other female flowers occur on lateral spikes (below the terminal spike). (USFWS, 2014)

Taxonomy

In a *A Flora of Utah*, Goodrich concluded that *Carex specuicola* belonged in *C. parryana* (in Welsh et al. 2003). That treatment was based on a limited number of specimens, particularly within Utah. A morphological re-evaluation of *C. specuicola*, using a large series of specimens, provides evidence that *C. specuicola* is a distinct species and the Utah “*parryana*” is a new species, *C. utahensis* (Reznicek and Murray 2013). The relationship between these three species may have implications for their conservation. (USFWS, 2014)

Historical Range

See Current Range.

Current Range

U.S.: Apache, Coconino, and Navajo counties, AZ; San Juan County, UT. Species is endemic to the Navajo Indian Reservation, Coconino, County, AZ.

Critical Habitat Designated

Yes; 6/7/1985.

Legal Description

On May 8, 1985, the U.S. Fish and Wildlife Service (Service) designated critical habitat (effective June 7, 1985) for *Carex specuicola* (Navajo sedge) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU), in Arizona (50 FR 19370-19374).

Critical Habitat Designation

The critical habitat designation for *Carex specuicola* includes one CHU in Coconino County, Arizona. The total area designated comprises about 809 square meters (about 0.15 acres), and contains all habitat presently known to be occupied by the species. (50 FR 19370-19374).

Arizona: Coconino County; Navajo Indian Reservation. A 40 x 5 meter rectangular area, with its long axis in the direction of seep-spring flow, around each of the following points: (1) Latitude 36 degrees 39' 53" N, longitude 110 degrees 48' 18" W; (2) latitude 36 degrees 40' 07" N. longitude 110 degrees 47' 55" W; and (3) latitude 36 degrees 40' 18" N. longitude 110 degrees

48' 15" W.

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 *Carex specuicola* critical habitat consists of one component (50 FR 19370-19374):

Primary constituent elements include moist shady to silty soils at shady seep-springs within the Navajo Sandstone Formation.

Special Management Considerations or Protections

The activities that may potentially affect the critical habitat of *Carex specuicola* or be affected by its designation are spring development and grazing. Spring - development could affect the free-flowing seep-springs upon which the species depends. Livestock trampling has contributed to some soil erosion on the steeper sandy soil sites at the Inscription House Ruin Spring site. Withdrawal of the critical habitat area from grazing (representing less than one Animal Unit Month and no grazing fees) or fencing may be warranted to protect the critical habitat from soil erosion or trampling. It is not expected that use of the seep-spring water for livestock watering will affect or be affected by the critical habitat designation because the watering sites are located away from the area where *Carex specuicola* is found. There is a coal mining operation about ten miles away from the critical habitat, but it is located in a different geologic formation and has a different water source than the critical habitat's water source. Small farms in the area may use excess water runoff, but are not expected to affect or be affected by the critical habitat designation. The BIA has informed the Service that it plans to monitor the critical habitat of *Carex specuicola* as part of its plans to develop an informal monitoring system for the resources under its jurisdiction. Currently, no plans for water development, farm use, or additional grazing permit applications are known that would involve Federal funds or permits for the area affected by the critical habitat designation. (USFWS, 1985)

Life History**Food/Nutrient Resources****Competition**

Adult: Non-native plant species

Food/Nutrient Narrative

Adult: *Carex specuicola* is a cliff-associated spring plant with a plant community referred to as a "hanging garden." Hanging gardens are complex, multi-habitat springs that emerge along geologic contacts, and seep, drip or pour onto the underlying substrate. They usually emerge from perched, unconfined aquifers in aeolian sandstone units. The hydrogeologic processes that result in these unique ecosystems also control the geomorphologic processes that shape the rock wall or associated canyons (Springer and Stevens 2009).

Reproductive Strategy

Adult: Vegetative

Lifespan

Adult: Unknown

Breeding Season

Adult: Flowering and fruit set occur from late June through September.

Key Resources Needed for Breeding

Adult: Wind for pollination

Reproduction Narrative

Adult: *Carex specuicola* reproduction appears to be mostly vegetative (Herman 1970), but no species-specific reproduction studies have been conducted. Pollination is likely by wind, as is predominant among sedges (Linder and Rudall 2005). Flowering and fruit set occur from late June through September (NNHP 2008), which is the only time *C. specuicola* can be positively identified. Suitable habitat can be identified year round.

Habitat Type

Adult: Moist, sandy to silty soils of shady seep-spring pockets or alcoves with somewhat limited soil development (NatureServe 2015).

Habitat Vegetation or Surface Water Classification

Adult: Riverine habitat: spring/spring brook; piñon-juniper woodland.

Dependencies on Specific Environmental Elements

Adult: Moist, sandy to silty soils of shady seep-spring pockets or alcoves with somewhat limited soil development (NatureServe 2015).

Spatial Arrangements of the Population

Adult: Isolated; dispersed.

Environmental Specificity

Adult: High

Tolerance Ranges/Thresholds

Adult: 1,280 to 2,300 meters (m)(4,200-7,600 feet[ft]) elevation; precipitation at 7.6 inches/year.

Site Fidelity

Adult: High

Habitat Narrative

Adult: *Carex specuicola* is a wetland obligate of springs, typically in alcoves associated with aeolian sandstone cliffs of varying height and slope (often vertical) at 1,280 to 2,300 meters (m)(4,200-7,600 feet[ft]) elevation (Rink and Licher, in prep) in piñon-juniper woodland. It rarely occurs on level terrain; three *C. specuicola* sites in Sheik Canyon, Utah, are located on the canyon floor (Rink and Hazelton, 2014). Water that supports *C. specuicola* is generally low in mineral content. However, there is one anomalous site, also in Sheik Canyon, described as a "crusty, mineral-rich hill slope spring" (Rink and Hazelton, 2014). Soil development in alcoves is limited; any soil present is sandy to silty, derived from sandstone bedrock and combined with

remnants of vegetation. Precipitation in the areas that the sedge has been found is approximately 7.6 inches a year. A cliff-associated spring with a plant community is referred to as a “hanging garden.” Hanging gardens are complex, multi-habitat springs that emerge along geologic contacts, and seep, drip or pour onto the underlying substrate. They usually emerge from perched, unconfined aquifers in aeolian sandstone units. The hydrogeologic processes that result in these unique ecosystems also control the geomorphologic processes that shape the rock wall or associated canyons (Springer and Stevens 2009). Originally found on Navajo Sandstone, *C. specuicola* is now also known from Cedar Mesa, De Chelly, and Kayenta sandstone formations. *C. specuicola* springs are often referred to as “seep-springs”. The plant community of hanging gardens predominantly includes *Aquilegia micrantha* (Bluff City columbine), *Epipactis gigantea* (giant helleborine), and *Mimulus eastwoodiae* (Eastwood monkeyflower). Associated sensitive and rare species include *Cirsium rydbergii* (Rydberg’s thistle), *Platanthera zothecina* (alcove bog-orchid), *Primula specuicola* (cave primrose), and *Zigadenus vaginatus* (alcove death camas) (NNHP 2001, 2005). Associated non-natives include *Agrostis semiverticillata* (water bentgrass), *Agrostis stolonifera* (creeping bentgrass; red top), *Bromus rubens* (red brome), *Bromus tectorum* (cheatgrass), *Poa pratensis* (Kentucky bluegrass), *Elaeagnus angustifolia* (Russian olive), *Taraxacum officinale* (dandelion), *Tamarix* sp. and *Polypogon* spp. (rabbitsfoot grass) (Phillips et al. 1981, NNHP 2012, NPS 2013).

Dispersal/Migration

Motility/Mobility

Adult: Low

Dispersal

Adult: None

Dispersal/Migration Narrative

Adult: Hanging gardens can be considered paleoreugia for the descendants of montane-boreal plant species. Paleoreugia are defined as habitats that are older than the surrounding matrix of vegetation, with extinction processes being more important than dispersal (Nekola 1999). Vicariance, a biogeographical speciation concept, hypothesizes that fragmentation of the environment promotes evolution by division of large populations into isolated subpopulations. This is in contrast to dispersal, another common speciation concept, which relies on dispersal of an organism into novel environments as a driver of speciation. Although vicariance and dispersal are both hypothesized to be drivers of speciation, the evidence supports vicariance as the mechanism behind the abundance of endemic plant species in hanging garden habitats.

Population Information and Trends

Population Trends:

Undetermined

Species Trends:

Undetermined

Population Growth Rate:

Unknown

Number of Populations:

68 EOs (USFWS, 2023)

Population Size:

>5,000

Resistance to Disease:

Unknown

Adaptability:

Unknown

Additional Population-level Information:

As of 2012, on the Navajo Nation there were 32 populations with enough status information for the NNHP to assign a viability rank. Of the 32 populations, 16 were assigned a rank of good or excellent viability. The rest were of fair viability, indicating some reason for concern. No populations were assigned a rank of poor viability. Although grazing effects were factored into the viability assessment, the long-term effects of grazing should be determined in order to fully assess the viability of livestock-accessible populations (NNHP 2012). Of the 14 populations known off the Navajo Nation, 7 were found in the last year (Rink and Hazelton 2014).

Population Narrative:

C. specuicola are reported using Elemental Occurrences (EOs), with an EO referring to one or more occupied hanging gardens within a single canyon, in a series of alcoves or a single alcove, within one kilometer of each other. While there remains some disagreement among researchers on the use of EOs versus populations or sites (Rink 2018), we use EOs here because surveyors have used them to document *C. specuicola* since 1986 as it provides a standardized, consistent tool to evaluate the status of the species (NatureServe 2004). In 2014, we knew of 57 *C. specuicola* Element Occurrences (EOs). We now know of 65 EOs comprised of 154 sites, which includes more sites at the northern end of the species range in Utah (Hopi Water Resources Program 2012, Rink 2017, Lewinsohn 2023, Rink 2023, Ventrella 2023, Wheeler 2023). Rink and Hazelton (2014) established nine monitoring plots, with procedures, for *C. specuicola* at nine sites, and recently established five more monitoring plots at new sites (Rink and Hazelton 2022). This brings the total number of monitoring plots in line with our recovery criteria to determine if there is long-term habitat stability (USFWS, 2023).

Threats and Stressors

Stressor: Climate change (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Increased temperature and altered precipitation patterns associated with climate change are previously unidentified threats that may have significant implications for this relict species that inhabits sites that depend on continuous discharge of small volumes of water. (USFWS, 2014)

Stressor: Water withdrawals (groundwater pumping) (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Water withdrawals from Colorado Basin aquifers that supply water to the seeps may solely and in combination with climate change pose a threat to the species. We lack long-term demographic data to assess population trends and specific information about the dynamics of the sources of water for seeps that support *C. specuicola*. Due to the relative rarity of its isolated aquatic habitats amid an arid region and its sensitivity to drying of the seeps, the species may be significantly affected by groundwater pumping. (USFWS, 2014)

Stressor: Livestock grazing (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: The main threats identified in the Recovery Plan, livestock-associated water development and livestock grazing/trampling, can significantly impact individual gardens, but are probably not a threat across all or a significant portion of the species range. However, impacts from these activities, grazing in particular, could exacerbate the effects of climate change and/or groundwater pumping and should continue to be monitored and factored in to future status assessments. (USFWS, 2014)

Recovery

Reclassification Criteria:

Not applicable.

Recovery Priority Number: 8

Delisting Criteria:

We will consider Navajo sedge for delisting when: (USFWS, 2019)

1. We can demonstrate the persistence of the species over time and across its range, as indicated by maintaining presence at 90% of known EORS for at least 15 years. This will be done through presence/absence surveys, with EORS being visited in a phased approach (e.g., several per year) within a time frame that may start retroactively beginning in 2011. Information such as viability may be a consideration in determining presence/absence. An EOR is defined as a "hanging 5 garden" (an assemblage of plants including Navajo sedge on a cliff) or a closely spaced group of hanging gardens in the same canyon within 1 kilometer of each other. (USFWS, 2019)

2. We can demonstrate long-term habitat stability, through monitoring and, if appropriate, modeling of hydrology. a. Monitoring would be conducted for at least 15 years on plots located in at least 13 sites, representing a range of environmental characteristics (geology, moisture, stressors), plant cover and composition, and broad geographic distribution. Each site would be visited annually at the same time of year and time of day. Visitation frequency may be adjusted semi-annually if supported by an analysis of initial findings. Monitoring protocol will follow Rink and Hazelton (2014) or a similarly rigorous methodology that documents both the extent of

Navajo sedge and moisture in the hanging garden. b. Modelling could involve the use of both hydro-geologic and climate change models to evaluate long-term effects of climate on the aquifers upon which Navajo sedge appears to rely. (USFWS, 2019)

Recovery Actions:

- 1. Protect existing populations of *Carex specuicola* by removing threats to the species and by managing its habitat. Navajo sedge populations occur on Navajo Trust lands. The BIA and Navajo Nation should cooperatively protect *Carex specuicola* by enforcing existing regulations and developing management policies to remove threats to the species. (USFWS, 1987)
- 2. Study the populations in their natural habitat. Because of the Navajo sedge's rarity and limited distribution, in-depth ecological and population biology studies are essential for its proper management. A comprehensive and ongoing monitoring program is a critical element in determining the present and future status of the Navajo sedge. Establishment of monitoring plots that are read yearly is necessary for determination of long-term population and habitat stability. The research should focus on the species' life history, environmental requirements, and vulnerability to threats. (USFWS, 1987)
- 3. Conduct experimental _growth studies and re-establish *Carex specuicola* on protected land. Because *Carex specuicola* has such a limited range, the potential for growing the species in the greenhouse and then transplanting plants into the field needs to be determined. These studies will assist in future re-establishment efforts. (USFWS, 1987)
- 4. Research traditional uses and potential uses of *Carex specuicola* by Navajo Nation and other Indian Tribes. Research on traditional uses of the Navajo sedge (e.g., medicinal, functional) should be conducted. If a traditional use is found, it would be important for the Navajo Nation to protect such a valuable cultural and economic resource. Traditional users could provide more locational information on the species. Potential, non-traditional uses of *Carex specuicola* should also be investigated. (USFWS, 1987)
- 5. Develop and implement a public education and awareness program for the preservation of *Carex specuicola*. To protect Navajo sedge populations on the Navajo Nation, an educational program for the Tribe needs to be developed. This program should enlist the support of the Inscription House Chapter and individuals affected because the species occurs within their Chapter. The cooperation of the Tribe is integral to the recovery and management of the Navajo sedge. The educational program may include pamphlets, interpretive signs, displays and slide shows for school and public meeting use. In addition to the educational program, tribal enterprises, the Public Health Service, and BIA agencies must be kept informed of the known occurrences and newly found populations of *Carex specuicola*. (USFWS, 1987)
- Recommendation for Future Action from 2014 5-year review: 1) We recommend revising the 1987 Navajo sedge (*Carex specuicola*) Recovery Plan, specifically to include recovery criteria and updated population, management, and climate information. (USFWS, 2014)
- Recommendation for Future Action from 2014 5-year review: 2) We recommend development of management plans by the respective land managing entities with the offered assistance of the USFWS. These management plans should address newly understood or emerging threats such as climate change and groundwater pumping. (USFWS, 2014)
- Recommendation for Future Action from 2014 5-year review: 3) We recommend standardized monitoring to determine demographic trends in *C. specuicola* populations. This

will allow the USFWS to determine trends in species or population stability, in support of Recovery Action 7. The USFWS can assist in coordinating this effort to facilitate consistency and comparability between the monitoring methods employed by each agency. (USFWS, 2014)

- Recommendation for Future Action from 2014 5-year review: 4) We recommend studying the dynamics of the aquifers upon which *C. specuicola* depends to understand how climate change, groundwater pumping, and other water use may affect seep discharge. This study would include an understanding of the sizes and connection of local and regional aquifers, and the distribution of seeps supporting *C. specuicola* within each of those aquifers; recharge and depletion rates; and the relative contributions of winter and summer precipitation. (USFWS, 2014)
- Recommendation for Future Action from 2014 5-year review: 5) We recommend quantifying the drought threshold for *C. specuicola* existence in hanging gardens. Threshold parameters would include soil moisture content and/or spring discharge rate, and variability in that moisture level over time. *C. specuicola* appears resilient to some amount of drought, but recovery of a population is dependent on the intensity, duration, and variability of the drought, along with site conditions. To determine these survival thresholds, data would need to be collected on a much finer scale than has been to date. (USFWS, 2014)
- Recommendation for Future Action from 2014 5-year review: 6) We recommend additional surveys for *C. specuicola* in Utah, particularly at the northern end of its range where large areas with apparent suitable geology are unsurveyed. (USFWS, 2014)
- Recommendation for Future Action from 2014 5-year review: 7) We recommend studying the reproductive strategy (including breeding success, seed viability, and pollination) and genetic diversity of *C. specuicola* to inform management for the species' long-term conservation. Genetic studies should include the relationships between *C. specuicola*, *C. parryana* and *C. utahensis*. (USFWS, 2014)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS We will work with our partners to implement the following recommended actions during the next five-year review period: • We recommend quantifying the drought threshold for *C. specuicola* in hanging gardens. Threshold parameters may include soil moisture content and/or spring discharge rate, and variability in that moisture level over time. *C. specuicola* appears resilient to some amount of drought, but persistence of a population is dependent on the intensity, duration, and variability of the drought, along with site conditions. To determine these thresholds, we need to collect data on a much finer scale than has been done to date. • We recommend studying the dynamics of the aquifers upon which *C. specuicola* depends to understand how climate change and local ground water pumping may affect seep discharge. This study should include an understanding of the aquifer sizes and distribution of seeps supporting *C. specuicola* associated with each of those aquifers; and recharge and depletion rates. • We recommend conducting studies on reproductive strategy (including breeding success, seed viability, and pollination) and dispersal mechanisms of *C. specuicola*. • We recommend continued monitoring of *C. specuicola* sites where livestock grazing occurs to better understand the timing, duration, and intensity of grazing so we may increase our understanding of long-term grazing effects on the plant. • We recommend we work with land management entities to develop management plans. These management plans should address newly understood or emerging threats such as climate change. • We recommend working with our partners to develop robust dispersal and colonization rates for *C. specuicola*. As workload allows, the Service could then use these rates to develop an additional delisting criterion addressing increasing *C. specuicola* abundance. • As workload allows, we

recommend reviewing and revising, as needed, designated critical habitat (USFWS, 2023).

References

USFWS. 2014. Navajo sedge (*Carex specuicola*)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Phoenix, Arizona. 31 pp.
https://ecos.fws.gov/docs/five_year_review/doc4442.pdf

USFWS. 1985. Determination of *Carex specuicola* to be a Threatened Species with Critical Habitat
Final Rule. 50 Federal Register 19370-19374 (May 8, 1985).

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Phoenix, Arizona. 31 pp.
https://ecos.fws.gov/docs/five_year_review/doc4442.pdf . USFWS. 2023. Navajo Sedge (*Carex specuicola*) 5-Year Status Review: Summary and Evaluation. USFWS. Arizona Ecological Services Office. Flagstaff, Arizona. 8 pp.

USFWS. 2019. Amendment 1 to Navajo Sedge Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 10 pp.

USFWS. 1987. Navajo Sedge Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 39 pp. https://ecos.fws.gov/docs/recovery_plan/870924.pdf

USFWS. 2023. Navajo Sedge (*Carex specuicola*) 5-Year Status Review: Summary and Evaluation. USFWS. Arizona Ecological Services Office. Flagstaff, Arizona. 8 pp.

SPECIES ACCOUNT: *Cyperus (=Mariscus) fauriei* (Alpine flatsedge)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/04/1994; Pacific Region (R1) (USFWS, 2016)

Physical Description

A perennial herb with tuberous underground stems that are covered with red-brown hairs (Figure 9) (Koyama 1990). Erect 3-angled stems 4-20 in (10-50 cm) tall are either single or several are grouped together. Linear leaves, 0.04-0.1 in (1-3.5 mm) wide, are equal to the stems in length. The basal portion of the leaf, which clasps the stem, (sheath) is red-brown. The flower cluster (inflorescence), 0.8-1.6 in (2-4 cm) long and 1.2-3.9 in (3-10 cm) wide, is subtended by thereto five unequal bracts, the lowest being the longest at 2.4-7.9 in (6-20 cm) long. Each flower cluster is composed of 3 to 10 spikes (unstalked flowers in unbranched clusters), which are 0.3-1.2 in (0.8-3 cm) long and 0.3-0.4 in (0.8-1 cm) wide. Each spike is composed of seven to nine small flattened flower units (spikelets) 0.2-0.3 in (4-8 mm) long, which spread with age. Bracts subtending each flower are yellow-brown, with red-brown specks or lines. The unopened fruits are 3-angled and elliptic, 0.05 in (1.2 mm) long and 0.03 in (0.7 mm) wide (USFWS, 1996).

Taxonomy

A member of the sedge (Cyperaceae) family. Strong and Wagner (1997), acknowledging a trend among sedge taxonomists to apply a broad circumscription to the genus *Cyperus* (e.g., Tucker 1994), accepted the synonymization of the genus *Mariscus* back into *Cyperus* for Hawaiian taxa (USFWS, 2012).

Historical Range

Historically, *Mariscus fauriei* was found on Molokai, Lanai, and the island of Hawaii (USFWS 2003a) (USFWS, 2012).

Current Range

It currently occurs on Molokai and Hawaii Island. It was last seen on Lanai in 1929 (USFWS 1996; 2003a) (USFWS, 2012).

Critical Habitat Designated

Yes; 3/19/2003.

Legal Description

On March 30, 2016, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Mariscus fauriei* (Alpine Flatsedge; aka *Cyperus fauriei*) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two detailed critical habitat units (CHUs), in Hawaii (81 FR 17790-18110).

On July 2, 2003, the U.S. Fish and Wildlife Service (Service), designated critical habitat pursuant to the Endangered Species Act of 1973, as amended (Act), for *Cyperus (=Mariscus) fauriei* on the island of Hawaii.

Critical Habitat Designation

The critical habitat designation for *Mariscus fauriei* includes two CHUs in Maui County, Hawaii with detailed unit information. There are also an unknown number of units on Lanai that contain

this species (number of units is unknown because detailed unit descriptions for Lanai are not available) (81 FR 17790-18110).

Molokai—Lowland Mesic—Unit 1 (and) *Palmeria dolei*—Unit 37—Lowland Mesic (and) *Pseudonestor xanthophrys*—Unit 37— Lowland Mesic This area consists of 3,489 ac (1,412 ha) of State land, and 5,281 ac (2,137 ha) of privately owned land, from Waianui Gulch to Mapulehu, in central Molokai. These units are occupied by the plants *Alectryon macrococcus*, *Ctenitis squamigera*, *Cyanea dunbariae*, *C. mannii*, *C. profuga*, *Cyperus fauriei*, *Cyrtandra filipes*, *Gouania hillebrandii*, *Labordia triflora*, *Neraudia sericea*, *Santalum haleakalae* var. *lanaiense*, *Schiedea lydgatei*, *S. sarmentosa*, *Silene alexandri*, *S. lanceolata*, *Spermolepis hawaiiensis*, and *Zanthoxylum hawaiiense*, and include the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the lowland mesic ecosystem (see Table 5). These units also contain unoccupied habitat that is essential to the conservation of these species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai— Lowland Mesic—Unit 1 is not known to be occupied by *Asplenium dielerectum*, *Bonamia menziesii*, *Canavalia molokaiensis*, *Clermontia oblongifolia* ssp. *brevipes*, *Cyanea procera*, *C. solanacea*, *Diplazium molokaiense*, *Festuca molokaiensis*, *Flueggea neowawraea*, *Isodendron pyriformis*, *Kadua laxiflora*, *Melicope mucronulata*, *M. munroi*, *M. reflexa*, *Phyllostegia haliakalae*, *P. mannii*, *P. pilosa*, *Sesbania tomentosa*, *Stenogyne bifida*, or *Vigna o-wahuensis*, or the forest birds, the akohekohe (*Palmeria dolei*) and kiwikiu (*Pseudonestor xanthophrys*), we have determined this area to be essential for the conservation and recovery of these lowland mesic species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Montane Mesic—Unit 1 (and) *Palmeria dolei*—Unit 42—Montane Mesic (and) *Pseudonestor xanthophrys*—Unit 42— Montane Mesic This area consists of 257 ac (104 ha) of State land, and 559 ac (226 ha) of privately owned land from Kamiloloa to Makolelau in central Molokai. These units are occupied by the plants *Alectryon macrococcus*, *Bidens wiebkei*, *Santalum haleakalae* var. *lanaiense*, and *Spermolepis hawaiiensis*, and include the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the montane mesic ecosystem (see Table 5). These units also contain unoccupied habitat that is essential to the conservation of these species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai— Montane Mesic—Unit 1 is not known to be occupied by *Asplenium dielerectum*, *Cyanea dunbariae*, *C. mannii*, *C. procera*, *C. solanacea*, *Cyperus fauriei*, *Kadua laxiflora*, *Melicope mucronulata*, *Neraudia sericea*, *Plantago princeps*, or *Stenogyne bifida*, or by the forest birds, the akohekohe (*Palmeria dolei*) and kiwikiu (*Pseudonestor xanthophrys*), we have determined this area to be essential for the conservation and recovery of these montane mesic species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

The critical habitat designation for *Cyperus* (=Mariscus) *fauriei* includes one unit totaling 313 acres in Hawaii County, Hawaii. The unit is Hawaii 19—*Mariscus fauriei*—a.

Hawaii 19—*Mariscus fauriei*—a [127 ha (313 ac)]: This unit contains a portion of Kipuka Puu Kou and lies completely within the South Point watershed. The unit provides habitat for 1 population of 300 mature, reproducing individuals of *M. fauriei* and is currently occupied by 12 individuals. This unit is essential to the conservation of *M. fauriei* because it supports an extant colony of this species and includes habitat that is important for the expansion of the present population, which is currently considered nonviable. This unit provides the southeasternmost critical habitat within the species' historical range. This unit is geographically separated from other critical habitat for this multi-island species within its historical range in order to reduce the likelihood of all recovery populations being destroyed by one naturally occurring catastrophic event.

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 *Mariscus fauriei* critical habitat consists of three components. Lowland dry (Lanai), Lowland mesic (Molokai) and Montane mesic (Molokai) (81 FR 17790-18110):

Ecosystem: Lowland Dry. Elevation: <3,300 ft (<1,000 m). Annual precipitation: <50 in (<130 cm). Substrate: Weathered silty loams to stony clay, rocky ledges, littleweathered lava. Canopy: *Diospyros*, *Myoporum*, *Pleomele*, *Santalum*. Subcanopy: *Chamaesyce*, *Dodonaea*, *Leptecophylla*, *Osteomeles*, *Psydrax*, *Scaevola*, *Wikstroemia*. Understory: *Alyxia*, *Artemisia*, *Bidens*, *Chenopodium*, *Nephrolepis*, *Peperomia*, *Sicyos*.

Ecosystem: Lowland Mesic. Elevation: <3,300 ft (<1,000 m). Annual precipitation: 50–75 in (130–190 cm). Substrate: Shallow soils, little to no herbaceous layer. Canopy: *Acacia*, *Diospyros*, *Metrosideros*, *Myrsine*, *Pouteria*, *Santalum*. Subcanopy: *Dodonaea*, *Freyinetia*, *Leptecophylla*, *Melanthera*, *Osteomeles*, *Pleomele*, *Psydrax*. Understory: *Carex*, *Dicranopteris*, *Diplazium*, *Elaphoglossum*, *Peperomia*.

Ecosystem: Montane Mesic. Elevation: 3,300–6,500 ft (1,000–2,000 m). Annual precipitation: 50–75 in (130–190 cm). Substrate: Deep ash deposits, thin silty loams. Canopy: *Acacia*, *Ilex*, *Metrosideros*, *Myrsine*, *Nestegis*, *Nothocestrum*, *Pisonia*, *Pittosporum*, *Psychotria*, *Sophora*, *Zanthoxylum*. Subcanopy: *Alyxia*, *Charpentiera*, *Coprosma*, *Dodonaea*, *Kadua*, *Labordia*, *Leptecophylla*, *Phyllostegia*, *Vaccinium*. Understory: Ferns, *Carex*, *Peperomia*.

Habitat features that are essential for this species include, but are not limited to, *Diospyros sandwicensis*-*Metrosideros polymorpha*-*Sapindus saponaria* dominated lowland dry forests, often on a lava substrate.

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*, *Isodendron 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.

The Service publishes this final rule acknowledging that they have incomplete information regarding many of the primary biological and physical requirements for this species. However, both the Act and the relevant court orders require the Service to proceed with designation at this time based on the best information available. As new information accrues, the Service may consider reevaluating the boundaries of areas that warrant critical habitat designation.

The following management actions are important in providing a conservation benefit to the species: feral ungulate control; wildfire management; nonnative plant control; rodent control; invertebrate pest control; maintenance of genetic material of the endangered and threatened plant species; propagation, reintroduction, and augmentation of existing populations into areas essential for the recovery of the species; ongoing management of the wild, outplanted, and augmented populations; maintenance of natural pollinators and pollinating systems, when known; habitat management and restoration in areas essential for the recovery of the species; monitoring of the wild, outplanted, and augmented populations; rare plant surveys; and control of human activities/access.

Life History

Food/Nutrient Resources

Lifespan

Adult: < 10 years (USFWS, 2012)

Reproduction Narrative

Adult: It is a short-lived perennial (fewer than ten years) (USFWS, 2012).

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Dry to moist shrublands and forests (NatureServe, 2015); lowland ohia or lama forest (USFWS, 2012)

Geographic or Habitat Restraints or Barriers

Adult: 380 - 3,673 ft. elevation (USFWS, 2012)

Habitat Narrative

Adult: Dry to moist shrublands and forests. On Molokai: ridge tops, gulch slopes, and gulch bottoms. On Hawaii: on old lava flows (NatureServe, 2015). On Molokai, *Cyperus fauriei* historically has been associated with *Diospyros sandwicensis* (lama)-dominated lowland dry forests, often on lava substrates, between 436 and 1,120 meters (1,430 and 3,673 feet) elevation. On Hawaii Island, the preferred historic habitat of *Cyperus fauriei* is lowland dry forest, often on a lava substrate, between 278 and 342 meters (913 and 1,123 feet) elevation (USFWS 2003c). The Kaloko population occurs at a lower elevation (116 meters [380 feet]) in dry *Metrosideros* forest (USFWS, 2012).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Not available

Number of Populations:

1 on Molokai (USFWS, 2020)

Population Size:

thousands (USFWS, 2020)

Population Narrative:

Current estimates of *Mariscus fauriei* through informal communications range from 2,000 to as many as 10,000 individuals (H. Oppenheimer, pers. comm. 2010; Ken Wood, National Tropical Botanical Garden, pers. comm. 2010). As of 2010, there were three known populations of *M. fauriei*: two small populations on Hawaii Island at Kamaoa-Puueo and Kaloko totaling 17 individuals, and a single large population on Molokai estimated to number in the thousands (USFWS 2010) (USFWS, 2012). Currently, there is one extended population of *Cyperus fauriei* on Moloka'i with an estimated thousands of individuals, and no known individuals on the island of Hawai'i. Monitoring of the Moloka'i populations, however, has not occurred during the last five years. A landscape-based assessment of climate change vulnerability for native plants of Hawai'i using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *C. fauriei* is vulnerable to the effects of climate change. No genetic materials are in storage, and no propagation, reintroduction, or threat control efforts are being conducted (USFWS, 2020).

Threats and Stressors

Stressor: Habitat degradation (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Ungulates: feral goats (*Capra hircus*), axis deer (*Axis axis*), pigs (*Sus scrofa*); invasive plants: *Ageratina adenophora* (Maui pamakani), *Andropogon virginicus* (broomsedge), *Erigeron karvinskianus* (daisy fleabane), *Lantana camara* (lantana), *Macroptilium* spp., *Melinis minutiflora* (molasses grass), *Pinus* spp., *Psidium cattleianum* (strawberry guava), *Rubus argutus* (blackberry), *Rubus rosifolius* (thimbleberry), *Schinus terebinthifolius* (Christmasberry); agricultural and urban development; landslides and flooding; fire (USFWS, 2012).

Stressor: Predation and competition (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Ungulate trampling and herbivory: feral goats, axis deer, pigs; invasive plants: *Buddleia asiatica* (dog tail), *Eucalyptus robusta* (swamp mahogany), *Pinus elliotti* (slash pine), *Fraxinus uhdei* (tropical ash) (USFWS, 2012).

Stressor: Climate change (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Climate change may pose a threat to this species. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species (USFWS, 2012).

Recovery**Reclassification Criteria:**

1. A total of five to seven populations should be documented on the Big Island (USFWS, 1996).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population (for short-lived perennials) (USFWS, 1996).
3. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered (USFWS, 1996).

Delisting Criteria:

1. A total of 8 to 10 populations of each taxon should be documented on the Big Island (USFWS, 1996).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population (for short-lived perennials) (USFWS, 1996).

3. Each population should persist at this level for a minimum of 5 consecutive years (USFWS, 1996).

Recovery Actions:

- Protect current populations and manage threats (USFWS, 1996).
- Conduct essential research (USFWS, 1996).
- Expand existing wild populations, as necessary (USFWS, 1996).
- Create new populations within historical range, as necessary (USFWS, 1996).
- Evaluate and validate recovery objectives (USFWS, 1996).
- Propagation and maintenance of ex situ genetic stock are necessary (USFWS, 1996).
- Molokai populations should be protected from deer and goats via fencing or other means (USFWS, 1996).
- Control of competing alien taxa, specifically *Optismenus hirtellus*, *Leucaena tuececephala* and *Schinus terebinthifolius*, is necessary on the Big Island (USFWS, 1996).
- Propagation and outplanting of ex situ stock will likely be needed in order to establish a sufficient number of populations and plants for recovery (USFWS, 1996).
- Efforts should be made to ensure that both Molokai and Big Island populations remain viable (USFWS, 1996).
- Captive propagation for reintroduction and storage: Collect cuttings or seed from tagged individuals, keeping close track of the maternal source for use in ex situ propagation. Collect seeds from all existing populations and send to at least two or three different venues for propagation and storage (USFWS, 2012).
- Reintroduction / translocation site selection – Study the possibility of reintroducing material from Molokai to appropriate and protected habitats on Lanai (USFWS, 2012).
- Ungulate exclosure: Complete the fence at Lanaihale. Construct fenced exclosures around all populations (USFWS, 2012).
- Ungulate control – Protect all populations against disturbances from feral ungulates (USFWS, 2012).
- Ecosystem-altering invasive plant species control – Control all invasive introduced plant species around all populations (USFWS, 2012).
- Fire protection – Develop and implement fire management plans for all wild and reintroduced populations (USFWS, 2012).
- Site / area / habitat protection: Develop and implement effective measures to reduce the impacts of agricultural and urban development. Implement erosion control measures to prevent landslides and flooding (USFWS, 2012).
- Federal register updates – Update the listed entity on 50 CFR 17 to match the currently recognized taxonomy (USFWS, 2012).
- Surveys / inventories: Because the species has a wide elevational range and can be difficult to distinguish from weedy sedges, more populations should be sought on Hawaii Island, especially in the Puu Waawaa area and slopes of Hualalai. A population census and monitoring of *Cyperus fauriei* on Molokai should be undertaken to confirm current population estimates and determine how much population numbers fluctuate from year to year. For recovery purposes, there is a need to clarify how many discrete populations exist on the island (USFWS, 2012).
- Alliance and partnership development – Work with Hawaii Division of Forestry and Wildlife and other land managers to initiate planning and contribute to implementation of

ecosystem-level restoration and management to benefit this species (USFWS, 2012).

- Threats research – Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species (USFWS, 2012).

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile.
<http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS. 2012. *Mariscus fauriei* (No common name)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

U.S. Fish and Wildlife Service. 1996. Big Island Plant Cluster Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. 202+ pp.

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).

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants

Final Designation and Nondesignation of Critical Habitat for 46 Plant Species From the Island of Hawaii, HI. Final rule. 68 FR 39623 - 39722 (July 2, 2003).

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

USFWS 2012. *Mariscus fauriei* (No common name) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii.

USFWS 2012. *Mariscus fauriei* (No common name) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. USFWS. 2020. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Cyperus fauriei* (no common name). 9 pp.

USFWS. 2012. *Mariscus fauriei* (No common name) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

SPECIES ACCOUNT: *Cyperus trachysanthos* (Pu`uka`a)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/10/1996; Pacific Region (R1) (USFWS, 2016)

Physical Description

A sedge with short rhizomes. Stems are densely tufted and 2 - 4.5 dm long (NatureServe, 2015).

Taxonomy

A member of the sedge family (Cyperaceae) (USFWS, 1999). Genus cosmopolitan, species endemic to Hawaiian islands. This name is maintained in Wagner et al. (NatureServe, 2015).

Historical Range

It was once known from Lanai, Molokai, Kauai, and Niihau (USFWS, 2010).

Current Range

It occurs on Oahu and Kauai (USFWS, 2013). Island Distribution: Found on Kauai and Oahu. Extirpated on Molokai, Niihau and Lanai (USFWS, 2021c)

Critical Habitat Designated

Yes; 2/23/2003.

Legal Description

On March 30, 2016, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Cyperus trachysanthos* (Pu`uka`a) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two detailed critical habitat units (CHUs), in Hawaii (81 FR 17790-18110).

On June 17, 2003, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Cyperus trachysanthos* (Pu`uka`a) under the Endangered Species Act of 1973, as amended (Act) (68 FR 35950-36348). On September 18, 2012 the Service published a Final Rule revising the 2003 designation of critical habitat designation for *Cyperus trachysanthos* (77 FR 57648-57862). The critical habitat designation includes 4 critical habitat units, which encompass approximately 112 acres on the Island of Oahu, Hawaii.

The critical habitat designation for *Cyperus trachysanthos* includes areas that were determined by the Service to be occupied at the time of listing, and also includes unoccupied suitable habitat that is essential to the conservation of this species by providing the PCEs necessary for reintroductions and expansion of the existing wild populations within their historical range.

On February 27, 2003, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Alectryon macrococcus* (Mahoe) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU), in Hawaii (68 FR 9116-9479).

Critical Habitat Designation

The critical habitat designation for *Cyperus trachysanthos* includes two CHUs in Maui County, Hawaii with detailed unit information. There are also an unknown number of units on Lanai that contain this species (number of units is unknown because detailed unit descriptions for Lanai are not available) (81 FR 17790-18110).

Molokai—Lowland Dry—Unit 1 consists of 24 ac (10 ha) of privately owned land, in a small gulch northwest of Mahana, in west-central Molokai. This unit includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the lowland dry ecosystem (see Table 5). Although Molokai—Lowland Dry—Unit 1 is not known to be occupied by *Bonamia menziesii*, *Cyperus trachysanthos*, *Eugenia koolauensis*, *Hibiscus brackenridgei*, *Kokia cookei*, or *Sesbania tomentosa*, we have determined this area to be essential for the conservation and recovery of these lowland dry species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Lowland Dry—Unit 2 consists of 589 ac (238 ha) of State land at Kamiloloa on the southern slopes of Molokai. This unit includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the lowland dry ecosystem (see Table 5). Although Molokai—Lowland Dry—Unit 2 is not known to be occupied by *Bonamia menziesii*, *Cyperus trachysanthos*, *Eugenia koolauensis*, *Hibiscus brackenridgei*, *Kokia cookei*, or *Sesbania tomentosa*, we have determined this area to be essential for the conservation and recovery of these lowland dry species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

The critical habitat designation for *Cyperus trachysanthos* includes 4 critical habitat units, covering two ecosystem types, which encompass approximately 112 acres on the Island of Oahu, Hawaii (77 FR 57648-57862). The designated critical habitats include: Oahu—Coastal—Units 9, 11, 12; Oahu—Lowland Dry—Unit 7.

Oahu—Coastal—Unit 9 [80 ac (33 ha)]. This area consists of 80 ac (33 ha) of State land in the coastal ecosystem on the leeward side of Makapuu Point (Puuokipahulu). Oahu—Coastal—Unit 11 [20 ac (8 ha)]. This area consists of 20 ac (8 ha) of privately owned land in the coastal ecosystem, at Ihiihilauakea on Koko Head (Kaihuokapuaa). Oahu—Coastal—Unit 12 [11 ac (5 ha)]. This area consists of 11 ac (5 ha) of City and County land in the coastal ecosystem, at Nonoula on Koko Head (Kaihuokapuaa).

Oahu—Lowland Dry—Unit 7 [15 ac (6 ha)]. This area consists of 15 ac (6 ha) of State land in the lowland dry ecosystem, in Leahi (Diamond Head) Crater within Diamond Head State Monument.

The critical habitat designation for *Alectryon macrococcus* includes one CHU in Kauai County, Hawaii (68 FR 9116-9479).

Kauai 11—*Cyperus trachysanthos*—a: This unit is critical habitat for *Cyperus trachysanthos* and is 272 ha (672 ac) on State land (Na Pali Coast State Park and Puu Ka Pele Forest Reserve) and extends along the coast from Makaha point to Hanakoa Valley. This unit provides habitat for six populations of 300 mature, reproducing individuals of the short-lived perennial *Cyperus trachysanthos* and is currently occupied with over 300 plants. This unit is essential to the

conservation of the taxon because it supports an extant colony of this species and includes habitat that is important for the expansion of the present population. It provides habitat for the westernmost range of the species. The habitat features contained in this unit that are essential for this species include, but are not limited to, wet sites (mud flats, wet clay soil, or wet cliff seeps) on seepy flats or talus slopes. This unit provides for six populations within this multi-island species' historical range on Kauai that are some distance away from the other critical habitat for this species, in order to avoid all recovery populations from being destroyed by one naturally occurring catastrophic event.

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 *Cyperus trachysanthos* critical habitat consists of one component. Lowland dry (Lanai and Molokai). Species- specific physical or biological features: seasonally wet soil and pond margins (81 FR 17790-18110):

Ecosystem: Lowland Dry. Elevation: <3,300 ft (<1,000 m). Annual precipitation: <50 in (<130 cm). Substrate: Weathered silty loams to stony clay, rocky ledges, littleweathered lava. Canopy: *Diospyros*, *Myoporum*, *Pleomele*, *Santalum*. Subcanopy: *Chamaesyce*, *Dodonaea*, *Leptecophylla*, *Osteomeles*, *Psydrax*, *Scaevola*, *Wikstroemia*. Understory: *Alyxia*, *Artemisia*, *Bidens*, *Chenopodium*, *Nephrolepis*, *Peperomia*, *Sicyos*.

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of *Cyperus trachysanthos* critical habitat consists of the following components according to ecosystem type (77 FR 57648-57862). Note: *Cyperus trachysanthos* occurs within the Coastal and Lowland dry ecosystems in the Waianae Mountain caldera complex and the Koolau Mountain caldera complex:

Oahu—Coastal—Units 9, 11, 12. (A) Elevation: <980 ft (<300 m). (B) Annual Precipitation: <20 in (<50 cm). (C) Substrate: Well-drained, calcareous, talus slopes; dunes; weathered clay soils; ephemeral pools; mudflats. (D) Canopy: *Hibiscus*, *Myoporum*, *Santalum*, *Scaevola*. (E) Subcanopy: *Gossypium*, *Sida*, *Vitex*. (F) Understory: *Eragrostis*, *Jacquemontia*, *Lyceum*, *Nama*, *Sesuvium*, *Sporobolus*, *Vigna*.

Oahu—Lowland Dry—Unit 7. (A) Elevation: <3,300 ft (<1,000 m). (B) Annual Precipitation: <50 in (<130 cm). (C) Substrate: Weathered silty loams to stony clay, rocky ledges, little weathered lava. (D) Canopy: *Diospyros*, *Myoporum*, *Pleomele*, *Santalum*, *Sapindes*. (E) Subcanopy: *Chamaesyce*, *Dodonaea*, *Leptecophylla*, *Osteomeles*, *Psydrax*, *Scaevola*, *Wikstroemia*. (F) Understory: *Alyxia*, *Artemisia*, *Bidens*, *Chenopodium*, *Nephrolepis*, *Peperomia*, *Plumbago*, *Sicyos*, *Sida*, *Waltheria*.

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of *Alectryon macrococcus* critical habitat consists of two components (68 FR 9116-9479):

(i) Wet sites (mud flats, wet clay soil, or wet cliff seeps) on seepy flats or talus slopes and containing the native plant species *Talipariti tiliaceum*; and

(ii) Elevations between 0 and 235 m (0 and 771 ft).

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*, *Isodendron 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; Maui Wet Cliff—Units 6 and 7; and Molokai Montane 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.

Special management considerations or protections are necessary throughout the critical habitat areas designated for *Cyperus trachysanthos* 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 feral ungulates, competition with nonnative species, hurricanes, landslides, rockfalls, flooding, fire, drought, and climate change. The reduction of these threats will require the implementation of special management actions within each of the critical habitat areas identified for this species.

Existing manmade features and structures within the boundaries of the mapped areas, such as buildings; roads; aqueducts and other water system features, including but not limited to pumping stations, irrigation ditches, pipelines, siphons, tunnels, water tanks, gaging stations, intakes, reservoirs, diversions, flumes, and wells; existing trails; campgrounds and their immediate surrounding landscaped area; scenic lookouts; remote helicopter landing sites; existing fences; telecommunications equipment towers and associated structures and equipment; electrical power transmission lines and distribution, and communication facilities and regularly maintained associated rights-of-way and access ways; radars, telemetry antennas; missile launch sites; arboreta and gardens; heiau (indigenous places of worship or shrines), and other archaeological sites; airports; other paved areas; and lawns and other rural residential

landscaped areas do not contain one or more of the primary constituent elements described for each species and therefore are not included in the critical habitat designations.

Life History**Food/Nutrient Resources****Lifespan**

Adult: < 10 years (USFWS, 2013)

Key Resources Needed for Breeding

Adult: Unknown (USFWS, 1999)

Reproduction Narrative

Adult: The family is monoecious (NatureServe, 2015). It is a short-lived perennial (fewer than 10 years) (USFWS, 2013). Reproductive cycles, longevity, specific environmental requirements, and limiting factors are unknown (USFWS, 1999).

Habitat Type

Adult: Terrestrial, wetland (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Coastal, marsh, seep, seasonally flooded wetland (NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: 0 - 771 ft. elevation (USFWS, 2010)

Habitat Narrative

Adult: In dry regions, often coastal, but in wet or seasonally wet situations such as in marshes, seeps, seasonally flooded wetlands, and clay soil which is wet during the winter but which dries out during the summer (NatureServe, 2015). *Cyperus trachysanthos* is usually found in wet sites (mud flats, wet clay soil, or wet cliff seeps) on flats or talus slopes at elevations between 0 and 235 meters (0 and 771 feet) (USFWS, 2010).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Seeds of this genus are consumed by birds and adhere with mud to the feet of birds (NatureServe, 2015).

Population Information and Trends**Population Trends:**

Not available

Number of Populations:

~5 (USFWS, 2021c)

Population Size:

~100-500 (USFWS, 2021c)

Population Narrative:

There are currently seven populations on Kauai and Oahu with a total of at least 700 individuals (USFWS, 2010).

Threats and Stressors

Stressor: Climate change (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Climate change may also pose a threat to *Cyperus trachysanthos*. However, current climate change models do not allow us to predict specifically what those effects, and their extent, would be for this species (USFWS, 2009).

Stressor: Habitat destruction and modification (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Threats to *Cyperus trachysanthos*' habitat on Oahu are habitat degradation by feral goats, pumping of wetlands for flood and mosquito control, and modifications to the wetland topography. On Kauai, the threat to habitat is loss of wetlands. In addition, climate change may pose a threat to this species (USFWS, 2009).

Stressor: Limited populations (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: The most recent 5-Year Review indicates that only two populations of 300 or more individuals exist. The small number of populations and individual plants increases the potential for extinction from random naturally occurring events (USFWS, 2014).

Stressor: Other species-specific threats (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: On Oahu, threats include competition with invasive introduced plant species, habitat disturbance by off-road vehicles, mowing, herbicide application, and runoff from nearby military activities (cleaning of vehicles, dumping of paints or thinners, or the use of pesticides). On Kauai, this species is threatened by a risk of extinction from naturally occurring events, such as landslides or hurricanes, due to the small number of individuals (USFWS, 2009).

Recovery

Reclassification Criteria:

1. A total of five to seven populations should be documented on islands where it now occurs or occurred historically (USFWS, 1999).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure with the following minimum numbers of mature individuals per population: 300 for short-lived perennials (USFWS, 1999).
3. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered (USFWS, 1999).

Delisting Criteria:

1. A total of 8 to 10 populations should be documented on islands where it now occurs or occurred historically (USFWS, 1999).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with the following minimum numbers of mature individuals per population: 300 for short-lived perennials (USFWS, 1999).
3. Each population should persist at this level for a minimum of five consecutive years (USFWS, 1999).

Recovery Actions:

- Protect habitat and control threats (USFWS, 1999).
- Expand existing wild populations (USFWS, 1999).
- Conduct essential research (USFWS, 1999).
- Develop and maintain monitoring plans (USFWS, 1999).
- Reestablish wild populations within the historic range (USFWS, 1999).
- Validate and revise recovery criteria (USFWS, 1999).
- Maintain adequate genetic stock (USFWS, 1999).
- Enhance wild populations and establish new populations (USFWS, 1999).
- Control competing alien plant species (USFWS, 1999).
- Protection from fire (USFWS, 1999).
- Protect plants from off-road vehicles (USFWS, 1999).
- Implement management recommendations for the Diamond Head population (USFWS, 1999).
- Surveys / inventories - Survey Oahu and Kauai populations to determine current number of individuals and if populations are increasing or decreasing in number (USFWS, 2013).
- Captive propagation for genetic storage and reintroduction - Continue collecting material for genetic storage and propagation for reintroduction, especially from those Oahu populations underrepresented in seed storage (all but Lualualei) (USFWS, 2013).
- Reintroduction / translocation - Continue reintroduction into suitable protected habitat, possibly at Koko Head or where *Marsilea villosa* is reintroduced at Haunama Bay or Makapuu on Oahu (USFWS, 2013).
- Alliance and partnership development - Initiate planning and contribute to implementation of ecosystem-level management and restoration to benefit this species (USFWS, 2013).

Conservation Measures and Best Management Practices:

- New Management Actions: • Surveys, inventories, and monitoring—The Wai‘anae Mountains Watershed Partnership (WMWP) is monitoring *Cyperus trachysanthos* on the U.S. Navy property at Lualualei on O‘ahu (WMWP 2017, 2018). • Captive propagation for genetic storage and reintroduction— o The Lyon Seed Conservation Laboratory reports storage of 72,661 seeds representing 57 founders from Kailua (Kawai Nui Marsh), 275,169 seeds representing founders in eight subpopulations from Kailua (Kawai Nui Marsh), storage of 353 seeds representing two founders from Makapu‘u, and 62,750 seeds representing founders (possibly three) from Lualualei (Lyon Arboretum 2019). o The National Tropical Botanical Garden (NTBG) reports storage of 3,231 seeds representing an unknown number of founders from Nualolo ‘Āina on Kaua‘i and 71 plants propagated from the same source (NTBG 2019). o Waimea Arboretum reported one plant in refugia in 2013, 40 plants in refugia in 2014, and 30 plants in refugia in 2015, from unidentified founders (Waimea Arboretum 2019). • Reintroduction— o On O‘ahu, 24 individuals representing an unknown number of founders from Mōkapu were reintroduced at Kawai Nui Marsh (Makiki Rare Plant Facility 2019). o On Kaua‘i, NTBG established a living collection of 19 individuals of *C. trachysanthos* at Limahuli representing the wild founders at Nu‘alolo ‘Āina (NTBG 2019).. (USFWS, 2020).
- Recommendations for Future Actions: There are no new threats or other significant new information regarding the species’ biological status since the last 5-year review in 2013. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2020. • Surveys and inventories—Conduct surveys for occurrences of *Cyperus trachysanthos* on the islands of O‘ahu and Kaua‘i, especially in areas of known occurrences, to determine its current status. • Climate change adaptation strategy—Assess the modeled effects of climate change on this species and use to determine future landscape needed for its recovery. • Captive propagation for genetic storage and reintroduction—Continue collecting material for genetic storage and propagation for reintroduction, especially from underrepresented populations on O‘ahu and Kaua‘i. • Reintroduction and translocation— o Continue reintroduction into suitable protected habitat on O‘ahu. o Determine appropriate protected reintroduction sites on Kaua‘i, Moloka‘i, and Lāna‘i. • Alliance and partnership development—Continue to work with the Wai‘anae Mountains Watershed Partnership, and other partners and land managers in planning and implementation of ecosystem-level restoration and management to benefit this species. (USFWS, 2020).

References

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

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed July 2016

USFWS 2013. *Cyperus trachysanthos* (puukaa) 5-Year Review Short Form Summary. Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii

USFWS 2010. *Cyperus trachysanthos* (puukaa) 5-Year Review Short Form Summary. Region 1/Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii. USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp.

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).

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Endangered Status for 23 Species on Oahu and Designation of Critical Habitat for 124 Species. Final Rule. 77 FR 57648-57862 (September 18, 2012)

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants

Final Designation or Nondesignation of Critical Habitat for 95 Plant Species From the Islands of Kauai and Niihau, HI

Final Rule. 68 FR 9116-9479 (February 27, 2003).

USFWS 2010. *Cyperus trachysanthos* (puukaa) 5-Year Review Short Form Summary. Region 1/Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

U.S. Fish and Wildlife Service. 1999. Recovery Plan for Multi-Island Plants. U.S. Fish and Wildlife Service, Portland, OR. 206 pages + appendices.

USFWS. 2009. *Cyperus trachysanthos* (Puukaa)

5-Year Review, Short Form Summary. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 8 pp.

USFWS. 2014. *Cyperus trachysanthos* (Puukaa)

5-Year Review, Short Form Summary. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 7 pp.

USFWS 2013. *Cyperus trachysanthos* (puukaa) 5-Year Review Short Form Summary. Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii.

USFWS. 2020. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Cyperus trachysanthos* (pu'uka'a). 9 pp.

SPECIES ACCOUNT: *Dendrobium guamense* (No common name)

Species Taxonomic and Listing Information

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

Physical Description

An orchid (USFWS, 2015).

Taxonomy

A member of the orchid family (Orchidaceae) (USFWS, 2015).

Historical Range

In addition to the current range, it occurred historically on Saipan (USFWS, 2015).

Current Range

It occurs on Guam, Rota, and Tinian, and was recently recorded for the first time on Aguiguan (Ames 1914, p. 14; Raulerson and Rinehart 1992, p. 98; Quinata 1994, in litt.; Raulerson 2006, in litt.; Costion and Lorence 2012, p. 66; Zarones et al. 2015a, in litt.; Zarones et al. 2015c, in litt.). Raulerson (2006, in litt.) cites *D. guamense* as also occurring on Agrihan, however, a voucher record or survey report to support this location could not be found (USFWS, 2015).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproduction Narrative

Adult: Not available

Habitat Type

Adult: Terrestrial, arboreal (USFWS, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Forest (USFWS, 2015)

Environmental Specificity

Adult: Narrow (USFWS, 2015)

Habitat Narrative

Adult: It occurs in the forest ecosystem. It is an epiphyte and occasional lithophyte. Raulerson and Rinehart (1992, p. 87), two renowned botanists who have studied extensively in the Marianas, stated that, although these orchids (referring to native orchids in the Marianas) appear abundant, the habitats are limited and in reality these orchids are quite rare (USFWS, 2015).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

50% decline in range (USFWS, 2015)

Species Trends:

Number of known individuals increasing (USFWS, 2015)

Number of Populations:

32 (USFWS, 2020)

Population Size:

~6,200 (USFWS, 2020)

Population Narrative:

This species has declined across at least 50 percent of its range (i.e., on Guam). Currently, there are at least 21 occurrences totaling approximately 1,250 individuals distributed on the islands of Guam, Rota, Tinian, and Aguiguan; this is more than twice as many individuals as were known at the time of the proposed rule. On Guam, there are 4 occurrences totaling fewer than 250 individuals (Quinata et al. 1994, p. 8; Harrington et al. 2012, in litt). On Rota, at least 15 occurrences of *D. guamense* are now known, and a recent survey team reported more than 700 individuals of *D. guamense* on the western third of Rota, represented by seedlings, juveniles, and flowering adults (Harrington et al. 2012, in litt.; Zarones et al. 2015c, in litt.). A survey team indicated that *D. guamense* is abundant across its preferred habitat on Rota, and subsequently suggested that the actual number of individuals could be as high as 35,000 (Zarones et al. 2015c, in litt.) (USFWS, 2015). There are approximately 6,200 individuals in 32 populations of *D. guamense* on Guam, Rota, Aguiguan and Tinian. There are only two wild individuals represented in ex situ collections, and there is no outplanting effort to date. There is some ongoing ungulate control for a small portion of individuals and there are plans in development for additional ungulate control, but the majority of populations have no ongoing threat control. (USFWS, 2020)

Threats and Stressors

Stressor: Development, urbanization, and military activities (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: In their 2015 Final SEIS ([http:// guambuildupeis.us/](http://guambuildupeis.us/)) (see “Historical and Ongoing Human Impacts,” above), the U.S. Department of Navy states that approximately 5,000 Marines will be relocated from Okinawa to Guam, accompanied by approximately 1,300 dependents, with a concurrent introduction of support staff and development of infrastructure, and increased use of resources such as water (Berger et al. 2005, p. 347; JGPO– NavFac, Pacific 2015, p. ES–3). The current preferred alternative sites on Guam for cantonment and live-fire training include the

Naval Computer and Telecommunications Station Finegayan and Northwest Field on Andersen AFB, where this species is known to occur. In November 2007, the people of Rota voted to legalize casino gambling to increase tourism, and two development projects have been proposed. Development around and within forested areas on Rota will also directly impact the forest habitat and individuals of this species (USFWS, 2015).

Stressor: Fire (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: Fire is a human-exacerbated threat to native species and native ecosystems throughout the Mariana Islands, particularly on the island of Guam. Fire can destroy dormant seeds of native species as well as plants themselves, even in steep or inaccessible areas. Successive fires that burn farther and farther into native habitat destroy native plants and remove habitat for native species by altering microclimate conditions to those favorable to alien plants (USFWS, 2015).

Stressor: Climate change (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: On a global scale, sea level is rising as a result of thermal expansion of warming ocean water; the melting of ice sheets, glaciers, and ice caps; and the addition of water from terrestrial systems (Climate Institute 2011, in litt.). Individuals of this species occur close to the coast in the adjacent forest ecosystem at or near sea-level and may be negatively impacted by sea-level rise and coastal inundation due to climate change (USFWS, 2015).

Stressor: Slug predation (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: The nonnative Cuban slug (*Veronicella cubensis*) is considered one of the greatest threats to native plant species on Pacific Islands (Robinson and Hollingsworth 2006, p. 2). These terrestrial mollusks are generalist feeders, and can attack a wide variety of plants, and switch food preferences if potential food plants change (Robinson and Hollingsworth 2006, p. 2). In addition, these slugs are known to attack orchids, which places this species at risk from slug predation (USFWS, 2015).

Stressor: Cattle ranching (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: Cattle ranching is gaining in popularity, and in the future the number of cattle is expected to double from 1,500 individuals (Bagnol 2014, in litt.; NRCS 2015, in litt.). The number of cattle ranchers on Tinian has risen from 10 or 12 in 2010, to 49 ranchers by 2014 (Bagnol 2014, in litt.). As numbers of cattle and ranchers increase on Tinian, there may be a somewhat greater risk of cattle potentially escaping and becoming feral. Both feral and domestic cattle can drastically alter the landscape (Wiles et al. pp. 176–177), and depending on the location and

amount of land designated as pasture land for domestic cattle, negative impacts to the forest ecosystem may be observed in the future (USFWS, 2015).

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Delisting Criteria:

Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- A conservation project on Rota, administered through the Water and Environmental Research Institute of the Western Pacific at the University of Guam, is aimed to analyze the island's hydrology, with the ultimate goal of protection of the Sabana Watershed and Talakhaya Springs (Keel et al. 2007, pp. 5, 22–23). Erosion control, revegetation, and water source preservation conducted as part of this project may provide protection to this species (USFWS, 2015).

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS – RECOMMENDATIONS FOR FUTURE ACTIONS** •
 Surveys and inventories—Continue to survey for *D. guamense* in historical locations and potentially suitable habitat. • Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species and those that compete with *D. guamense* or modify their habitat. • Fire monitoring and control—Develop and implement fire prevention management plans. • Captive propagation for genetic storage and reintroduction—Collect seeds for storage and propagation efforts for maintenance of genetic stock. • Ungulate predation or herbivory—Construct ungulate exclosures, or erect strategic fencing, around naturally occurring *D. guamense* populations to protect this species and associated habitat from feral ungulates. • Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change • Alliance and partnership development—Initiate planning and contribute to implementation of ecosystem-level restoration and management, especially between Guam and the CNMI to benefit this taxon. • Research life history and habitat associations to better identify information that will help guide recovery, for example: specific micro-habitat conditions, pollinators, reproduction, etc. (USFWS, 2020)
- **Current Management Actions:** • Surveys and inventories – o *Dendrobium guamense* are surveyed for in suitable habitat that may be cleared or degraded for various projects with the intention of avoiding impacts as much as possible. o Joint Region Marianas (JRM) surveyed for ESA-listed species, including *D. guamense*, at the Naval Munitions Site (NMS) and Naval Base Guam Telecommunication Site. Surveys were conducted to document locations and estimate population densities in sites that are proposed for ungulate exclusion and forest restoration (JRM 2019). • Captive propagation for genetic storage o The Guam Plant Extinction Prevention Program (GPEPP) propagates *D. guamense*. In 2018, GPEPP had 8 plants in their nursery representing one wild individual on Mount Alifan, and 134 plants from 1 wild individual from Mangilao (Univ. of Guam). In addition, there are 320 explant representing that wild Mangilao individual in tissue culture (GPEPP 2018). • Habitat protection – o An island-wide Habitat Conservation Plan for Guam, that would provide a collaborative and comprehensive approach to endangered species conservation on non-federal lands, is beginning to

be developed (USFWS 2020). o A 2020 Memorandum of Understanding between JRM and the USFWS outlined a mutual understanding regarding the intentions and future considerations of a Department of Defense Readiness and Environmental Protection Integration Initiative (REPI) to address conservation of upland vegetation communities (DON and USFWS 2020). o Native forest ecosystems are being restored in multiple plots on the NMS within fenced areas where ungulates and invasive plants have been removed (JRM 2019). o Plans to exclude deer and pigs from 165 acres of North Haputo Ecological Reserve Area with ungulate fencing have been developed (USFWS 2017). o Range Fire Management Plan for Marine Corps Ranges on Guam. A range fire management plan to reduce range/wildfire potential, protect and enhance natural and cultural resources, integrate applicable permit and reporting requirements and implement ecosystem management goals, sustainable training, and objectives already supported on existing Marine Corps installations is being drafted. (USFWS, 2020)

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS 2015. Endangered and Threatened Wildlife and Plants

Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497.

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497. USFWS. 2020. *Dendrobium guamense* (no common name) 5-Year Review Summary and Evaluation U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, HI. 17 pp.

USFWS. 2015. Endangered and Threatened Wildlife and Plants

USFWS. 2020. *Dendrobium guamense* (no common name) 5-Year Review Summary and Evaluation U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, HI. 17 pp.

SPECIES ACCOUNT: *Digitaria pauciflora* (Florida Pineland crabgrass)

Species Taxonomic and Listing Information

Listing Status: Threatened; 11/6/2017; Southeast Region (R4) (USFWS, 2017)

Physical Description

Digitaria pauciflora is a small perennial clump-grass, appearing blue-green to gray with reddish-brown stems, typically 0.5 to 1 m (1.5 to 3 ft) tall. The leaves form a subtle zig-zag pattern as the leaf blades come off the stem at an angle. The flowers are dull green and very small, and are borne on wispy spikes on the ends of the leafy stems, with usually only a few flower clusters forming per clump of grass. Stolons (aboveground horizontal stems) are not present. Inflorescence branches have been known to produce roots infrequently at their nodes, and these have been observed producing new ramets (belowground horizontal stems) that allow for vegetative spread. (USFWS, 2017)

Taxonomy

Digitaria pauciflora was first described in 1928, based on specimens collected in 1903, and was later placed in the genus *Syntherisma* (Small 1933). Subsequent authors (Hitchcock 1935; Webster & Hatch 1990; Wunderlin 1998) have retained it in the genus *Digitaria*. *D. pauciflora* was absent from collections from 1939 until 1973, when it was rediscovered in Everglades National Park. The online Atlas of Florida Vascular Plants uses the name *Digitaria pauciflora*. The Integrated Taxonomic System (ITIS 2016), NatureServe (2016), and the Florida Department of Agriculture and Consumer Services (FDACS) indicates that its taxonomic status is accepted. It has been determined after careful review of all taxonomic data that *Digitaria pauciflora* is a valid taxon. The only synonym is *Syntherisma pauciflora* (Hitchcock) Hitchcock ex Small (ITIS 2016). (USFWS, 2017)

Historical Range

The historical range of *D. pauciflora* consists of central and southern Miami-Dade County, Florida, along the Miami Rock Ridge, from southern Miami to Long Pine Key region of ENP, a range of approximately 42 mi. (USFWS, 2017)

Current Range

In Miami-Dade and Monroe counties in Florida, in the Long Pine Key area of Everglades National Park and Big Cypress National Park. (USFWS, 2017)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual. Plants can also spread clonally via rhizomes. (USFWS, 2017)

Breeding Season

Adult: The species produces flowers from summer to late fall on both new and older growth, some plants have been observed to finish seeding as late as December. (USFWS, 2017)

Reproduction Narrative

Adult: Reproduction is sexual, with new plants generated from seeds. The species produces flowers from summer to late fall on both new and older growth, some plants have been observed to finish seeding as late as December. Plants can also spread clonally via rhizomes. (USFWS, 2017)

Habitat Type

Adult: Seasonally flooded ecotone between pine rockland and marl prairie, and with some overlap into both habitats (USFWS, 2017)

Habitat Vegetation or Surface Water Classification

Adult: Forest/Woodland, Woodland-Conifer

Dependencies on Specific Environmental Elements

Adult: Periodic fire is extremely important to maintaining habitat for this species. (USFWS, 2017)

Environmental Specificity

Adult: Very narrow; specialist or community with key requirements scarce; species occurs in ecotonal regions between marl prairies and pine rocklands, usually a strip approx. 200 m across at widest point. (NatureServe 2015)

Tolerance Ranges/Thresholds

Adult: The plants can stand partial inundation with fresh water for a portion of the year, but do not tolerate salinity. (USFWS, 2017)

Habitat Narrative

Adult: *Digitaria pauciflora* occurs predominantly within the seasonally flooded ecotone between pine rockland and marl prairie, although the species may overlap somewhat into both habitats. Plants can withstand inundation with fresh water for one to several months each year. These habitats are maintained by regular fire, and are prone, particularly marl prairie, to annual flooding for several months during the wet season. (USFWS, 2017)

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Unknown (USFWS, 2017)

Number of Populations:

2 extant populations (USFWS, 2023)

Population Size:

Estimates: 100,000 to 200,000 individuals within Everglades National Park; 100 - 1,000 at Camp Everglades; >10,000 within the Big Cypress National Park (USFWS, 2023)

Population Narrative:

In 2002, *Digitaria pauciflora* was discovered within the Lostmans Pines region of Big Cypress National Park in Monroe County, Florida. Subsequent surveys for the species within BCNP have documented up to nine occurrences, some of which contain an estimated 500-600 plants. The rangewide population estimate for *D. pauciflora* is 100,000 to 200,000 individuals at Long Pine Key, and greater than 10,000 individuals within Big Cypress National Park. (USFWS, 2017). Currently, Florida crabgrass is extant only in two locations, ENP and BCNP. The Long Pine Key region of ENP, has a population estimate greater than 200,000 individuals (Maschinski and Lange 2015). In 2007, the BCNP population estimate was greater than 10,000 individual plants (Bradley, pers. comm. 2007). While Florida crabgrass populations remain abundant within ENP and BCNP, these areas represent only half of the species' historical range (USFWS, 2023).

Threats and Stressors

Stressor: Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Exposure:

Response:

Consequence:

Narrative: Habitat loss, fragmentation and degradation, and associated pressures from increased human population are major threats this species. These threats are expected to increase as remaining pine rocklands and other habitats are lost to development, placing these plants at greater risk. This species may be impacted when pine rocklands are converted to other uses or when lack of fire causes the conversion to hardwood hammocks or other unsuitable habitats. On public lands, including National Park Service lands and Miami-Dade County-owned lands, implementation of prescribed fire has not been sufficient because of legal constraints (permitting requirements) and inadequate funding. Any populations of this species found on private property could be destroyed due to development. Although efforts are being made to conserve natural areas and apply prescribed fire, most pine rocklands remain in poor fire condition, and the long-term effects of large-scale and wide-ranging habitat modification, destruction, and curtailment will last into the future, while ongoing habitat loss due to population growth, development, and agricultural conversion continues to pose a threat to this species outside of conservation lands.

Stressor: Inadequacy of Existing Regulatory Mechanisms

Exposure:

Response:

Consequence:

Narrative: This species is found on Federal, State and County lands. NPS regulations provide protection at Everglades National Park and Big Cypress National Preserve. These two sites continue to support the largest and best managed populations. State regulations provide protection against trade, but allow private landowners or their agents to clear or remove species on the Florida Regulated Plant Index. State Park regulations provide protection for plants within Florida State Parks. The Natural Forest Communities program in Miami is designed to protect rare and important upland (non-wetlands) habitats in south Florida; however, this regulatory strategy has several limitations that reduce its ability to protect this plant and its habitat. Although many populations of this species are afforded some level of protection because they are on public conservation lands, especially Federal lands, existing regulatory mechanisms vary in strength and scope, and do not provide substantive protection of habitat at this time. They have

not led to a sufficient reduction of threats posed to these plants by a wide array of sources. (USFWS, 2017)

Stressor: Other Natural or Manmade Factors Affecting Its Continued Existence

Exposure:

Response:

Consequence:

Narrative: Threats from other natural or manmade factors to this species include nonnative, invasive plants; management practices (such as mowing); recreation (including off-road vehicle use), effects from small population size and isolation; limited geographic range; and stochastic events including hurricanes, storm surges, and wildfires. Additionally, this plant is particularly vulnerable to the effects of climate change, including sea level rise, as changes in the water table, increased soil salinity from partial inundation, and storm surge will likely result in vegetation shifts in the decades prior to the fully anticipated sea level rise. Some of these threats (e.g., nonnative species) may be reduced on public lands due to active programs by Federal, State, and County land managers. Many of the remaining populations of this plant are small and geographically isolated, and genetic variability is likely low, increasing the inherent risk due to overall low resilience of these plants. The threats act together to impact populations of this species. (USFWS, 2017)

Stressor: Climate Change (USFWS, 2023)

Exposure:

Response:

Consequence:

Narrative: Climate change poses a significant threat to the two remaining populations of Florida crabgrass. Sea level rise is expected to greatly reduce the land area within the range of Florida crabgrass in the coming decades (Sweet et al. 2022). Increased frequency and duration of severe hurricanes, increased precipitation rates, and magnitude of storm surges (Intergovernmental Panel on Climate Change 2019) have the potential to modify or destroy the remaining habitat for Florida crabgrass throughout its historical range. While the hydrologic requirements for Florida crabgrass is not well understood, increased inundation for longer periods than normal or increased soil salinity from storm surges has the potential to harm individual organisms as well as negatively impact the integrity of the habitat (USFWS, 2023).

Recovery

Reclassification Criteria:

Not defined.

Delisting Criteria:

Not defined.

Recovery Actions:

- Not defined.
- Determine the effects (positive or negative) from Everglades restoration and other hydrologic manipulations and changes.
- Continue ex situ conservation work.
- Control exotic plant species where the species is found.

- Determine the frequency with which prairies within Big Cypress National Park burn, and work with partners to adjust accordingly.
- Assist in management recommendations and accurate evaluation of site suitability for possible reintroduction by conducting research on the habitat requirements, plant associates, and response to hydroperiod shifts and fire.
- Assess the potential impacts of off-road vehicles on occurrences within Big Cypress National Park.
- Evaluate the feasibility of reintroduction if suitable habitat exists or can be restored at the Luis C. Martinez U.S. Army Reserve Station in the Richmond Pine Rocklands and at sites with indefinite occurrences and potentially suitable habitat.

Conservation Measures and Best Management Practices:

- **RECOMMENDED FUTURE ACTIVITIES** This species does not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities which are included below. Recovery Activities • Maintain current populations of the pine rockland habitat with an approved management plan including a prescribed fire regimen. • Conduct extensive eradication of invasive plants within known populations. • Develop a translocation/reintroduction plan to identify potential recipient sites for reintroducing or establishment of populations within the historical range. Emphasis should be put on the known extirpated populations in table 1 as well as Nixon Smiley Preserve, Lucille Preserve, Tamiami Complex Addition, and Snapper Creek Pineland. • Identify and restore patches of historically wetter environmentally endangered lands within Florida crabgrass's historic range. • Establishing partnerships with private landowners to promote conservation easements and landowner agreements within remaining Florida crabgrass habitats. Monitoring / Research Activities • Conduct regular monitoring of populations to better understand species trends. • Survey extensively in and around the Gum Slough/Stair Steps area of BCNP to better understand the extent of this population. • Research species demographics such as life history and ecology with an emphasis on understanding the hydrological periods required by the species. • Evaluate the 16,000 seeds collected for viability in long-term cold storage. Determine storage lifespan and the rate at which banks should be replenished. • Map the extant populations of Florida crabgrass and identify remaining suitable habitat within the species range. Outreach Activities: • Increase public awareness and appreciation for native plants and habitats. • Attend public events when appropriate to improve the communities understanding of management techniques and policies, such as prescribed fire, in pine rockland habitats (USFWS, 2023).

References

USFWS. 2017. Endangered Species Status for *Dalea carthagenensis* var. *floridana* (Florida Prairie-clover), and Threatened Species Status for *Sideroxylon reclinatum* ssp. *austrofloridense* (Everglades Bully), *Digitaria pauciflora* (Florida Pineland Crabgrass), and *Chamaesyce deltoidea* ssp. *pinetorum* (Pineland Sandmat). Final Rule. 82 FR 46691-46715 (October 6, 2017).

USFWS. 2017. Endangered Species Status for *Dalea carthagenensis* var. *floridana* (Florida Prairie-clover), and Threatened Species Status for *Sideroxylon reclinatum* ssp. *austrofloridense* (Everglades Bully), *Digitaria pauciflora* (Florida Pineland Crabgrass), and *Chamaesyce deltoidea* ssp. *pinetorum* (Pineland Sandmat). Final Rule. 82 FR 46691-46715 (October 6, 2017). USFWS. 2023. Florida Pineland Crabgrass (*Digitaria pauciflora*) 5-Year Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Vero Beach, Florida. 12 pp.

USFWS. 2017. Endangered Species Status for *Dalea carthagenensis* var. *floridana* (Florida Prairie-clover), and Threatened Species Status for *Sideroxylon reclinatum* ssp. *austrofloridense* (Everglades Bully), *Digitaria pauciflora* (Florida Pineland Crabgrass), and *Chamaesyce deltoidea* ssp. *pinetorum* (Pineland Sandmat). Final Rule. 82 FR 46691-46715 (October 6, 2017).

USFWS. 2023. Florida Pineland Crabgrass (*Digitaria pauciflora*) 5-Year Review: Summary and Evaluation. Southeast Region. Florida Ecological Services Field Office. Vero Beach, Florida. 12 pp.

USFWS 2013. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Digitaria pauciflora* (Florida Pineland Crabgrass). U.S. Fish and Wildlife Service, Southeast Region (Region 4)

March 4, 2013. 18 p.

SPECIES ACCOUNT: *Erythronium propullans* (Minnesota dwarf trout lily)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/26/1986; Great Lakes-Big Rivers Region (R3) (USFWS, 2015)

Physical Description

An herbaceous, spring-blooming, perennial member of the lily family. The single flower is 8 - 14 mm long. The stamens are heteromorphic. Flower color ranges from pinkish to pale violet to almost flesh to whitish or almost gray white. The elliptic lanceolate leaves taper to a sharp point ending in a tip 0.8 to 3.5 mm long with inrolled edges (Morley 1987) (USFWS, 1987).

Taxonomy

Its most constant taxonomic character is its method of vegetative reproduction, from which the species takes its name "propullans" (sprouting forth) (USFWS, 1987).

Historical Range

The historical range encompasses 275 square miles in Rice and Goodhue counties, MN (USFWS, 1987).

Current Range

E. propullans is restricted to portions of the Straight River, Cannon River, Little Cannon River, Zumbro River, and Prairie Creek watersheds in Minnesota (USFWS, 2011).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Primarily vegetative (USFWS, 1987; USFWS, 2021); sexual (USFWS, 2011).

Lifespan

Adult: 1 year (see habitat narrative)

Dependency on Other Individuals or Species

Adult: *Andrena carlini* (USFWS, 1987)

Breeding Season

Adult: April - May (USFWS, 1987)

Key Resources Needed for Breeding

Adult: Insect pollinators (USFWS, 1987)

Reproduction Narrative

Adult: The species is a spring ephemeral, flowering from late April to mid May. Vegetative production of a new individual is accomplished by the formation of a second bulb at the tip of a runner that arises from the underground stem of flowering plants. The flowers are principally visited by a small bee, *Andrena carlini* (Banks 1980). Other species of bees, flies and beetles infrequently visit the Minnesota trout lily (Banks 1980). Fertile seeds have been found only when it is pollinated by the white trout lily (Banks 1980). Indications are that pollen sterility is very high (Banks 1980). Therefore, the predominant mode of reproduction is vegetative. 1.29 bulbs can be expected at the end of the growing season for each original bulb in the colony (USFWS, 1987). There is a low level of sexual reproduction in *E. propullans* (USFWS, 2011). No new information regarding DTL biology or life history has become available since the last 5-year review. Published research reveals that DTL rarely, if ever, produces seeds (Banks 1980; Morley 1982). It appears that this species reproduces largely, if not entirely, by asexual means through the production of offshoots. Attempts to artificially propagate DTL generally have been unsuccessful (USFWS, 2021).

Habitat Type

Adult: Terrestrial (USFWS, 2011)

Habitat Vegetation or Surface Water Classification

Adult: Floodplain, wooded slopes (USFWS, 2011); riparian (USFWS, 1987)

Geographic or Habitat Restraints or Barriers

Adult: Coarse soils (USFWS, 2011); occurs between 860 - 1190 ft. elevation (USFWS, 1987)

Spatial Arrangements of the Population

Adult: Colonial (USFWS, 1987)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 1987)

Habitat Narrative

Adult: *E. propullans* does "poorly in coarser soils" and may be restricted to areas underlain by Decorah shale bedrock, "probably because of the finer texture soils derived from this stratum" (N. Sather in litt. 2 July 2008, Sather 2009a). *E. propullans* typically occurs in "rich north-northwest or northeast-facing slopes dominated by maple-basswood stands and adjoining flood plains dominated by lowland hardwoods" (Sather 2009b:2) (USFWS, 2011). It is often found in circular clones or colonies. Sites are associated with streams or abandoned stream channels. Elevation range from 860 to 1190 ft. (Morley 1978). It is believed that this species may be intolerant of shade, because it completes its annual lifecycle before the canopy is fully expanded. Preferred soils are loamy to sandy-loam texture, neutral to slightly acidic, and well drained (USFWS, 1987). The species' distribution is related to the distribution of Decorah shale as the underlying bedrock layer, probably because of the finer texture soils derived from this stratum (Sather 2009a). The species' preferred habitat appears to be maple basswood forests on slopes and ravines or floodplain forests (USFWS 2011). (USFWS 2021)

Dispersal/Migration

Dispersal

Adult: Low (inferred from USFWS, 2011)

Dispersal/Migration Narrative

Adult: Movement of plants dislodged by floods may have been an effective mode of dispersal historically (Pleasants & Wendel 1989:1146; U.S. Fish and Wildlife Service 1987:6). The likelihood of a propagule settling in suitable habitat after being transported by floods today, however, may be low due to habitat fragmentation (USFWS, 2011).

Population Information and Trends**Population Trends:**

Declining (USFWS, 2011)

Species Trends:

Declining (USFWS, 2011)

Number of Populations:

~500 (USFWS, 1987)

Population Size:

Up to 10,000 plants (USFWS, 1987)

Population Narrative:

E. propullans is less genetically diverse than *E. albidum*, from which it is derived, but it appears to possess high genetic diversity compared to other species with small historical ranges that reproduce mostly or entirely vegetatively (Pleasants & Wendel 1989). In addition to the apparent increase in threats to the species since 1987, both long- and short-term population trends are mostly negative at consistently monitored sites (USFWS, 2011). It is estimated that 500 colonies exist. Colonies range in size from one plant to more than 500 individuals (USFWS, 1987). No new sites for DTL have been documented since the last review, but the Clinton Falls Dwarf Trout Lily SNA was established in 2011 immediately after the previous 5-year review was completed. Results of these efforts indicate that managed populations in Minnesota may be declining. However, metrics for monitoring populations and determining protected status for DTL should be revised to adequately observe trends. There does not appear to be any single event or disturbance to attribute declines (Anderson 2019). Climate change and associated largescale precipitation events throughout the season are new and emerging threats, which alter floodplain habitats by scouring away the finer textured soils where DTL grows and depositing sediments on established populations (Anderson 2019). Exotic species, developmental anomalies, logging associated with agriculture and urban development, incompatible recreational uses, and herbicides continue to be threats for DTL (USFWS 2011; Anderson 2019). Preserving wild plants in their natural habitat appears to be the best option for ensuring survival of this rare species. (USFWS, 2021).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2013)

Exposure:

Response:**Consequence:**

Narrative: There are at least two other threats to *E. propullans* habitat that are mentioned in documents completed after approval of the recovery plan – vegetation management within a power line corridor at Rice County Park – Cannon River Wilderness Area (Sather 1998) and residential development upslope of populations on the east side of the Cannon River “in and north” of Faribault, MN (Sather 1998). Sather (1998, p. 10) stated that “customary vegetation management” in the power line corridor could directly impact the *E. propullans* and indirectly affect them by increasing erosion. Increased residential development may threaten *E. propullans* if it leads to increased runoff and erosion (USFWS, 2013).

Stressor: Grazing (USFWS, 2013)

Exposure:**Response:****Consequence:**

Narrative: In the range of *E. propullans*, white-tailed deer (*Odocoileus virginianus*) grazing on spring ephemeral forbs is mainly focused on *Erythronium* species (*E. propullans* and *E. albidum*). At high deer densities (25-35/km²) grazing appears to reduce the number of *Erythronium* plants (Augustine 1997:126). At high (25- 35/km²) and low (4-11/km²) deer densities, Augustine (1997:22) found that about 8% and 1% of *Erythronium* stems were grazed, respectively (USFWS, 2013).

Stressor: Flooding (USFWS, 2013)

Exposure:**Response:****Consequence:**

Narrative: Increases in the extent of impervious surfaces, climate change, and habitat fragmentation are all factors that may have transformed flooding from an episodic disturbance with relatively neutral and, potentially, beneficial impacts to *E. propullans* into a threat to its persistence. Floods resulting from intense rain events may have devastating impacts on *E. propullans* populations in floodplains. All sites on steep slopes and in lowland areas, for example, may be vulnerable to erosion and siltation caused by heavy rainfall, whereas populations on “gentle midslopes” or in ravines may escape major damage (Sather 1998). Erosion, especially gully formation, may also be an impact of increased urbanization where it affects runoff. About 37 percent of *E. propullans* populations occur on highly erodible slopes (Sather 2009a); several are in areas near developed urban areas (Fig. 8). In addition, coarsening of soils that may result from increases in flood frequency and intensity could degrade floodplain habitats of *E. propullans* (N. Sather, pers. comm. 1 July 2008) (USFWS, 2013).

Stressor: Invasive species (USFWS, 2013)

Exposure:**Response:****Consequence:**

Narrative: Buckthorn is “highly competitive with native species”, which it can suppress to establish itself under low light conditions (Tanentzap & Bazely 2009:306). A variety of practices may be implemented, at considerable cost, to control buckthorn (Delanoy & Archibold 2007; Pergams & Norton 2006). Effective control may require herbicide use. In addition, some actions that remove established buckthorn plants may harm *E. propullans* by disturbing soil, facilitating

garlic mustard invasion, and damaging or dislodging *E. propullans* and other native herbaceous plants (Sather 2009b). Non-native earthworms are also emerging as a threat to *E. propullans*. At Nerstrand-Big Woods State Park, for example, exotic earthworms may be “contributing to sheet erosion, the spread of garlic mustard and buckthorn, and general decline of the ground flora of the woodland” (D. Anderson, in litt. 2011). According to Frelich et al. (2006), “Earthworms reduce the thickness of organic layers, increase the bulk density of soils and incorporate litter and humus materials into deeper horizons of the soil profile, thereby affecting the whole soil food web and the above ground plant community.” (USFWS, 2013).

Stressor: Climate change

Exposure:

Response:

Consequence:

Narrative: Climate change and associated large-scale precipitation events throughout the season are new and emerging threats, which greatly alter floodplain habitats by scouring away the finer textured soils where DTL grows (Anderson 2019). Such intense flood events deposit sand and other sediments (as much as 12 inches) on top of known populations, create new channels that pass through previously documented populations, and erode slopes where populations occur. (Anderson 2019) (USFWS, 2021).

Stressor: Herbicides (lawn applications)

Exposure:

Response:

Consequence:

Narrative: Any new or revised criteria would need to address the following threats, which were not addressed in the 1987 recovery plan: exotic species [including honeysuckle (*Lonicera* spp.), buckthorn (*Rhamnus cathartica*) and dame’s rocket (*Hesperis matronalis*)], developmental anomalies, increased flooding, and perhaps also the offsite application of (lawn) herbicides.

Recovery

Reclassification Criteria:

A minimum of 400 naturally occurring colonies (clones) in at least 10 geographically and ecologically distinct sites are adequately protected and managed to assure their continued existence (USFWS, 2011).

Delisting Criteria:

A total of 500 colonies in at least 15 sites, representing the entire extant range of the species, are adequately protected and managed (USFWS, 2011).

Recovery Actions:

- Provide adequate protection for selected sites of naturally occurring colonies of Minnesota trout lilies, and the habitats in which they occur (USFWS, 1987).
- Provide appropriate management at each protected site (USFWS, 1987).
- Monitor population trends at known sites (USFWS, 1987).
- Conduct appropriate research into the biology, management and habitat requirements of the Minnesota trout lily to allow evaluation of trends (USFWS, 1987).
- Reestablish populations at known historic locations (USFWS, 1987).

- Provide appropriate public information (USFWS, 1987).
- Cooperate with a plant developmental morphologist or geneticist to identify potential causes of abnormal floral development (USFWS, 2011).
- Review the recovery criteria (U.S. Fish and Wildlife Service 1987:17) and revise it to include clear and measurable criteria to ensure the protection of *E. propullans* populations in a variety of habitat types and geographic areas. For example, describe the specific habitat types (e.g., hill and floodplain) and watersheds or other geographic units within which a certain number of populations should be protected. Sather's (1998) six "conceptual metapopulations" and "highest priority sites" may be a good starting point for this review (USFWS, 2011).
- Review the recovery criteria (U.S. Fish and Wildlife Service 1987:17) and revise it to include an appropriate metric and set of methods to monitor population status. As describe above, the use of "colonies" to monitor population status is not sufficiently objective and is often impractical to implement in the field. The establishment of permanent monitoring plots and periodic monitoring may be the best solution. At River Bend Nature Center, Sather (2009b) recommends "initiating a student project in conjunction with the Nature Center to count only the colonies along the path each year, with periodic DNR counts of colonies in the grid, perhaps on a three to five year cycle." (USFWS, 2011).
- Review the recovery criteria (U.S. Fish and Wildlife Service 1987:17) and current protection status of all *E. propullans* habitats to determine whether it would be appropriate to consider *E. propullans* habitats outside of SNAs to be sufficiently protected. Describe mechanisms, as appropriate, that may be necessary to ensure protection of habitats outside SNAs. A memorandum of understanding (MOU), for example, between DNR Division of Ecological Resources and another DNR division, agency or organization may be sufficient to ensure appropriate levels of habitat protection and management into the foreseeable future. MOUs used for this purpose, however, should include mechanisms to ensure implementation of appropriate management and other critical elements. Any new or revised recovery criteria should be accompanied by a clear description of the types of ownerships or conditions (e.g., easements) that would be sufficient to consider *E. propullans* habitat to be protected. Sather's (2004b) protection analysis and a comprehensive review of current ownership and conservation status of *E. propullans* habitats may serve as a model for considering potential revisions to the recovery criteria (USFWS, 2011).
- Identify any specific habitats that must be protected to conserve *E. propullans*. Confirm and describe the current ownership of these habitats and develop plans – site-specific, if necessary – to describe actions necessary to ensure conservation of *E. propullans* in each area. Identify governmental and non-governmental organizations that may have the capability to implement necessary protection and management (USFWS, 2011).
- Evaluate watersheds containing *E. propullans* habitats to determine the proportion of surface area in each that is covered by connected impervious surfaces. Monitor flooding event intensity and duration in watersheds containing *E. propullans*. Study the effects of flooding events on *E. propullans* (USFWS, 2011).
- Work with governmental units, as necessary, to ensure that protection of *E. propullans* habitat is considered before any government-owned sites are sold or transferred (USFWS, 2011).
- Review the distribution of anomalous developmental traits among *E. propullans* habitats and consider revising recovery criteria to emphasize protection of a minimum number of sites with few or no anomalies. The southernmost site on the Straight River, just north of

Clinton Falls in Steele County, for example, may currently be free of anomalous plants (N. Sather, pers. comm. 1 July 2008) (USFWS, 2011).

- Use a Global Positioning Device to record the boundaries of colonies at all sites to which observers have access, except where data collection may damage the habitat – i.e., where foot traffic on steep slopes would damage vegetation and soils, and where seed of garlic mustard or other invasive species is present and likely to be spread by observers (USFWS, 2011).
- Determine whether any additional research is necessary to better understand which invasive species compete with *E. propullans* and to understand the nature of this competition; dames rocket (*Hesperis matronalis*) at River Bend Nature Center may be a focus of this review and may be integrated into the environmental education program there (USFWS, 2011).
- Develop strong general recommendations for addressing invasive species threats to *E. propullans* that would be applicable to all sites. Evaluate control methods to ensure that they would not harm viability of *E. propullans* populations. In these efforts, coordinate with potential partners (e.g., Rice-Scott County Weed Management Area) to maximize benefits to *E. propullans* (USFWS, 2011).
- Ensure that regular monitoring is adequate to track trends in anomalous plant development. Where abnormal flower development is observed, permanent plots should be established within which the number of anomalous plants (and their types) should be counted along with the number of normal plants (USFWS, 2011).
- Determine whether *E. propullans* genetic material should be added to the existing genetic bank at Holden Arboretum. It may be prudent, for example, to add material from additional populations – most or all material now in bank may be from one population. Berry Botanical Garden may help to estimate costs associated with this action (USFWS, 2011).
- Public education efforts may be important in and near Faribault, Minnesota. Consider the development of „citizen science? programs that would allow private citizens to participate in *E. propullans* monitoring and conservation activities (USFWS, 2011).
- Prepare a plan to comprehensively survey areas where undiscovered populations of *E. propullans* may exist along “(P)ortions of the Straight River and its tributaries upstream of the Steele County line” where landowner permission to conduct searches of suitable habitat has yet to be secured. Carry out surveys “in this highly developable corridor” (Sather 2009a) (USFWS, 2011).
- Describe the role that the two ex situ populations of *E. propullans* should play in the species? recovery in light of the Service's Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act (65 Federal Register 56916- 56922). Consider working with the managers of the habitats occupied by these populations at Minnesota Landscape Arboretum and Eloise Butler Wildflower Garden to maximize their value to the species? conservation – e.g., as reservoirs of genetic material, sources for reintroductions, research into effects of herbicides, developmental anomalies, etc. (USFWS, 2011).
- Evaluate the vulnerability of *E. propullans* to potential climate change. As a start, use the NatureServe Climate Change Vulnerability Index (USFWS, 2011).
- Work with the City of Faribault to better understand the impacts of the city's activities on *E. propullans* and to explore opportunities for the city to contribute to the species? recovery (USFWS, 2011).
- Evaluate the nature (e.g., species composition) and extent of invasion by non-native earthworm species in the range of *E. propullans*. Determine whether actions should be

taken to protect *E. propullans* habitats from earthworms (USFWS, 2011).

Conservation Measures and Best Management Practices:

- The USFWS provides the following recommendations: 1. Revise the recovery criteria (USFWS 1987) to include an appropriate metric and set of methods to monitor population status. The use of “colonies” to monitor population status is not sufficiently objective and is often impractical to implement in the field because they often merge overtime (USFWS 2011). The establishment of permanent monitoring plots and periodic monitoring may be the best solution. At River Bend Nature Center, Sather (2009b) recommends “initiating a student project in conjunction with the Nature Center to count only the colonies along the path each year, with periodic MNDNR counts of colonies in the grid, perhaps on a three to five year cycle.” 2. Revise the recovery criteria (USFWS 1987) to include clear and measurable criteria to ensure the protection of DTL populations in a variety of habitat types and geographic areas. Describe the specific habitat types (e.g., hill and floodplain) and watersheds or other geographic units within which a certain number of populations should be protected. Sather’s (1998) six “conceptual metapopulations” and highest priority sites” may be a good starting point for considering potential revisions to the recovery criteria. 3. Review the recovery criteria (USFWS 1987) and current protection status of all DTL habitats to determine whether it would be appropriate to consider habitats outside of SNAs to be sufficiently protected. Describe mechanisms, as appropriate, that may be necessary to ensure protection of habitats outside SNAs. Any new or revised recovery criteria should be accompanied by a clear description of the types of ownerships or conditions (e.g., easements) that would be sufficient to consider habitat to be protected. Sather’s (2004b) protection analysis and a comprehensive review of current ownership and conservation status of DTL habitats may serve as a model for considering potential revisions to the recovery criteria. 4. Revise recovery criteria to address the following additional threats: exotic species [including honeysuckle (*Lonicera* spp.), buckthorn (*Rhamnus cathartica*) and dame’s rocket (*Hesperis matronalis*)], developmental anomalies, increased flooding associated with climate change, and perhaps also the offsite application of (lawn) herbicides. 5. More potential sites for DTL need to be located and all sites where occurrences are found need to be protected. Invasive species that are found in the vicinity of DTL should be removed. (USFWS 2021)

References

USFWS 2011. Minnesota Dwarf Trout Lily (*Erythronium propullans*) 5-Year Review: Summary and Evaluation. August 2011. U.S. Fish and Wildlife Service Twin Cities Field Office Bloomington, Minnesota

U.S. Fish and Wildlife Service 1987. *Erythronium propullans* Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 31 pp.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed May 2016.

U.S. Fish and Wildlife Service 1987. *Erythronium propullans* Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 31 pp. USFWS. 2021. Minnesota Dwarf Trout Lily (*Erythronium propullans*). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. Minnesota-Wisconsin Field Office Bloomington, Minnesota. 19 pp.

U.S. Fish and Wildlife Service 1987. *Erythronium propullans* Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 31 pp. USFWS. 2021. Minnesota Dwarf Trout Lily (*Erythronium propullans*). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. Minnesota-Wisconsin Field Office Bloomington, Minnesota. 19 pp.

USFWS. 2021. Minnesota Dwarf Trout Lily (*Erythronium propullans*). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. Minnesota-Wisconsin Field Office Bloomington, Minnesota. 19 pp.

U.S. Fish and Wildlife Service. 1987. *Erythronium propullans* Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 31 pp.

USFWS 2011. Minnesota Dwarf Trout Lily (*Erythronium propullans*) 5-Year Review: Summary and Evaluation. August 2011. U.S. Fish and Wildlife Service Twin Cities Field Office, Bloomington, Minnesota.

U.S. Fish and Wildlife Service 2021. Minnesota Dwarf Trout Lily (*Erythronium propullans*). 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service. Minnesota-Wisconsin Field Office Bloomington, Minnesota. 19 pp.

SPECIES ACCOUNT: *Fritillaria gentneri* (Gentner's Fritillary)

Species Taxonomic and Listing Information

Listing Status: Endangered; 1/10/2000; Pacific Region (R1)

Physical Description

Fritillary is a perennial herb arising from a fleshy bulb producing numerous small rice-grained bulblets. The plant also produces several large scales surrounded by 10 to 150 small rice-grained bulblets per plant (USFWS 2003). Fritillary forms large maroon to bright reddish flowers with yellow mottles that are easily observed in the early spring. The flowers are solitary, or in bracted racemes, 1 to 7 (rarely more) on long slender pedicels. The 2.5 to 4.0 cm bell-shaped flower has segments that bend more or less outward, at times straight, but are not strongly recurved like the common scarlet fritillary (*Fritillaria recurva*) (USFWS, 2016).

Taxonomy

The species was originally described in 1951 by Helen M. Gilkey. (USFWS, 2016)

Current Range

Scattered localities in southwest Oregon along the Rogue and Illinois River drainages in Josephine and Jackson Counties, Oregon; also known from two sites, about one mile apart, in far northern California (OBIC 2008).(USFWS, 2016)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Largely reproduces asexually (USFWS, 2016)

Breeding Season

Adult: Flowers from mid-April to early June (USFWS, 2016)

Reproduction Narrative

Adult: Fritillary emerges from the ground in early February, flowers from mid-April to early June, and is dormant from mid-August to mid-January (USFWS 2003). Non-flowering fritillaries greatly outnumber flowering plants in natural populations, and are recognizable only by their single ovate to lanceolate basal leaf, indistinguishable from several other common related fritillaries. Due to poor and erratic seed production, bulblet production and disbursement are the principal means of Gentner's fritillary propagation. Older research (Amsberry and Meinke 2002) documented erratic, extremely low seed production, and poor viability in the species (2.3% seed production), indicating that the plant largely reproduces asexually. However, inter-population fruit-set of *F. gentneri* x *F. gentneri* crosses was much higher, with 48.9% seed production and with good seed viability (Amsberry and Meinke 2007) (USFWS, 2016).

Habitat Type

Adult: Forest/woodland (USFWS, 2016)

Environmental Specificity

Adult: Broad (inferred from USFWS, 2016)

Habitat Narrative

Adult: Fritillary occurs in a variety of forested habitats including oak woodlands dominated by Oregon white oak (*Quercus garryana*), mixed hardwood forest dominated by California black oak (*Quercus kelloggii*), Oregon white oak, and madrone (*Arbutus menziesii*), and coniferous forests dominated by madrone and Douglas-fir (*Pseudotsuga menziesii*) (USFWS 2003). The 25 soil types that the plant has been known to occur on are Abegg, Beckman-Colestine complex, Brader-Debenger complex, Caris-offenbacher complex, Cornutt-Dubakelia complex, Dubakella-Pearsoll complex, Farva, Heppsie, Heppsie-McMullin complex, Holland, Langellain, Langellain-Brader complex, Manita, McNull-Medico complex, McMullin-Rockoutcrop complex, McNull, McNull-Medco complex, McNull-McMullin complex, Ruch, Tallowbox, Tatouche, Vannoy, Vannoy-Voorhies complex, Woodseye-rockoutcrop complex and Xerothents-Dumps complex (USFWS 2003). The soil types most commonly supporting the plant are Vannoy and Vannoy-Voorhies complex (USFWS, 2016).

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Unknown (USFWS, 2016)

Resiliency:

Resiliency was assessed using the single greatest observation of flowering individuals from the previous 10 years (2011 to 2021) of site monitoring data (flowers), Bureau of Land Management (BLM) Geographic Biotic Observations of unmonitored sites (single observations), and Oregon Department of Agriculture reintroduction and augmentation monitoring data (leaves). Sites were classified as high resiliency (met or exceeded the estimated minimum viable population [MVP] with 17 or more flowers; estimated to contain 1,200 to 1,700 individuals), moderate resiliency (at least 50 percent of the MVP value with 8 to 17 flowers; estimated to contain 600 to 1,199 individuals), or low resiliency (lacking enough information, or below 50 percent of MVP with fewer than 8 flowers; estimated to contain fewer than 600 individuals). A total of 29 monitored and 4 unmonitored sites were high resiliency, 14 monitored and 2 unmonitored sites were moderate resiliency, and 53 monitored and 30 unmonitored sites were low resiliency. Sites within 0.5 kilometer (km) (0.3 mile) of one another were considered to be a population for purposes of determining resiliency. Thus, several of the populations comprise more than one site (USFWS 2022, pp. 46-47, Table 16); the 81 sites comprise 44 populations. Population resiliency was determined by combining site monitoring data with 2017–2019 augmentation/reintroduction vegetative counts, resulting in a resiliency condition based on the estimated MVP (U.S. Fish and Wildlife Service 2022, p. 32). Of the 44 identified populations, 16 are high resiliency, 6 are moderate resiliency, and 22 are low resiliency (USFWS, 2022).

Representation:

Representation of Gentner's fritillary includes diversity in occupied habitats, adequate genetic diversity, and sufficient population sizes needed for long-term viability. Gentner's fritillary is found in a variety of upland habitat ranging from oak- to conifer-dominated habitat, in a range of elevations. The degree of genetic diversity within Gentner's fritillary populations is important for several reasons. First, diversity within and among populations should confer greater resistance to pathogens and parasites, and greater adaptability to environmental stochasticity (random variations such as annual rainfall and temperature patterns) and changes in climate patterns. Second, low genetic diversity within interbreeding populations leads to a higher incidence of inbreeding, and potentially to inbreeding depression (USFWS, 2022).

Redundancy:

Redundancy of Gentner's fritillary appears adequate to withstand catastrophic events; 49 sites have high and moderate resiliency, with at least 5 high- or moderate-resiliency sites occurring in each recovery unit. Species distribution modeling resulted in identifying 514,485 hectares (ha) (1,271,320 acres) of habitat in three different categories: 253,031 ha (625,254 acres) of marginal, 176,149 ha (435,274 acres) of suitable, and 85,304 ha (210,792 acres) of highly suitable habitat, throughout the potential range of Gentner's fritillary (USFWS 2022, p. 13, Figure 6). Most of the modeled habitat has not been adequately surveyed to know whether the species occurs there; when it is surveyed, additional sites are likely to be found (USFWS, 2022).

Number of Populations:

~274 (USFWS, 2022)

Population Size:

~303,161 (USFWS, 2022)

Population Narrative:

There are approximately 138 occurrences of fritillary. A high number of 1,955 flowering plants were observed on 50 BLM monitoring sites lands in 2004, but flower plant counts have been lower since then, even though seven new monitoring sites were added. The lowest years were 2006 and 2007 when less than 1,000 flowering plants were observed on the monitoring sites. In the last six years, flower fritillary counts have remained above 1,100. Eight occurrences contained 100 flowering plants or more in the last ten years, with surveyors recording a high of 602 flowering plants at the Pilot Rock Lower occurrence on the Cascade Siskiyou National Monument in 2013. The rest of the populations have fluctuated between 0 to 96 flowering plants (Siskiyou BioSurvey 2014). Flowering individuals are the most efficient to monitor because flowers are easily detected while leaves are less noticeable and cannot be positively identified to species. Available science has not established that a low number of flowering plants indicate an unhealthy population. The Pickett Creek population has been the subject of a long-term demography study. In this population both flowering plants and vegetative leaves are documented. Flowering plant counts have steadily declined at this site over the last 13 years. In 2012, the lowest recorded numbers of flowering individuals were recorded (46 flowering individuals). However, the estimated total population size (both vegetative and flowering plants) based on density plots in the upper and below-road subpopulations has not consistently declined, but has fluctuated throughout the course of the study from a low of 6,715 in 2006 to a high of 17,684 in 2003 (Giles-Johnson et. al 2013). For the last 14 years, the BLM has monitored fritillary flowers and leaves on 58 sites across all four recovery units and within 43 occurrences (Siskiyou Biosurvey LLC 2014). While results indicate that the number of flowering fritillary

plants at most sites fluctuate annually, the overall flowering plant total indicates a seven-year increasing trend. With the discovery of over 40 new occurrences since the species was listed in 1999, the distribution of fritillary is more extensive than previously understood (S. Friedman, USFWS, pers. comm. 2015). Approximately 309 flowering plants have been discovered in the new occurrences, which approximate an increase of 15,450 m² or 3.8 acres. The most recent fritillary plant total across the range of the species is 2,907 flowering plants; up from 1,696 flowering plants at the time of 2003 recovery plan publication (USFWS 2003) (USFWS, 2016). Currently, there are approximately 274 occupied Gentner's fritillary sites in Oregon (271) and California (3). Of the known sites, 96 sites are routinely monitored. Based on monitoring data and reported data from unmonitored sites, we conservatively estimate that 303,161 plants are distributed across the known range of the species in 4 recovery units (Table 1) (USFWS 2022, p. 18, Figure 8). Gentner's fritillary is a rare species and we do not anticipate that it is likely to ever be as widely distributed as the closely related *F. recurva* and *F. affinis*. Federal, state, county or municipal ownership accounts for 98 percent of known Gentner's fritillary sites. In the SSA (USFWS 2022, pp. 42-51) the only available metric to evaluate condition was abundance. Therefore, resiliency, redundancy, and condition are based on abundance (USFWS, 2022).

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS, 2016)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: The effects of continued development, as documented in the original listing rule and recovery plan, have likely continued and may have caused increased habitat loss and fragmentation on private land. Examples of development described in the recovery plan include agricultural, municipal, residential, and road development. For example, the 40-acre Jacksonville Woodlands occurrence cluster is particularly threatened by development (USFWS 2003). It is likely that some suitable habitat for *Fritillaria gentneri* could have been lost due to the development pressures in southern Oregon. The threat of habitat destruction can be reduced through land acquisition, land protection, non-native invasive plant control strategies, and compatible land use by landowners. For example, at least 5.7 acres (2.3 hectares) in the Jacksonville Woodlands occupied by *Fritillaria gentneri* were transferred from private ownership to the City of Jacksonville's Beekman Woods and received permanent protection from development. In 2008, after acquisition of 1,750 acres (708 hectares) of private land by The Nature Conservancy within and adjacent to Table Rocks in Jackson County a new 12-acre (5 hectare) *F. gentneri* population was discovered at Upper Table Rock. The land supporting this population was recently transferred to BLM and is afforded protection. At another location, a 15-acre property, supporting approximately 20 flowering plants, a conservation easement was established to ensure their long-term protection (Mergenthaler, pers. comm. 2012). While it is challenging to estimate habitat loss on private land, approximately 33 acres of *F. gentneri* habitat has been set aside for conservation. (USFWS, 2016)

Stressor: Disease or Predation (USFWS, 2016)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Evidence of herbivory of *Fritillaria gentneri* by deer (*Odocoileus* sp.), elk, rabbits, (*Sylvilagus* spp.) turkeys (*Meleagris gallopavo*), livestock, and insects is frequent and widespread (USFWS 2003; Amsberry and Meinke 2005, Siskiyou BioSurvey LLC 2014) because the plant produces highly palatable flowers. Deer can harm *F. gentneri* populations by eating leaves and flowers which can result in the death of individual plants. Fossorial mammals (e.g., gophers) and insects are also predators on *Fritillaria* sp. bulbs (Amsberry and Meinke 2005). However, loss of flowers is not anticipated to be a major threat since the species rarely produces seed and usually self-propagates through clonal bulb production. Fossorial mammal activity is also a probably and possibly important bulb dispersal vector. - The impact of livestock grazing practices on *Fritillaria gentneri* plants and habitat is not well understood. It appears that *F. gentneri* populations have persisted over the last ten years in areas with low cattle densities. Overgrazing, on the other hand, is expected to result in a complete loss of plants. It is unknown to what extent grazing can benefit the species, but possibly by reducing competing vegetation, suitable habitat can be maintained (Siskiyou BioSurvey LLC 2014). Further studies are needed to increase our knowledge of livestock grazing compatibly with *F. gentneri*. - As mentioned in the recovery plan, fungal infections were identified as a threat to the species at the time the listing rule was published, in 1999. Since then, only sporadic fungal infections have been noted and these appear to be transient and not pose an imminent threat to the species (USFWS 2003; Siskiyou BioSurvey LLC 2013). (USFWS, 2016)

Stressor: Non-native invasive plants (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: A major threat associated with development and roads is the spread of non-native invasive plants. At several locations *Fritillaria gentneri* is threatened by encroachment from yellow star-thistle, tree-of-heaven (*Ailanthus altissima*), Scotch broom, as well as various non-native grasses (USFWS 2003; Maddox et al. 2005). The Jacksonville Woodlands occurrence cluster is facing these particular threats (USFWS 2003). In 2001, *Fritillaria gentneri* habitat and plants were inadvertently impacted at the Jacksonville Cemetery due to excavation activities. Subsequently a yellow starthistle infestation colonized a large section of the property due to the disturbance. (USFWS, 2016)

Stressor: Litter and thatch accumulation (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: When *Fritillaria gentneri* plants are covered by a thick accumulation of duff (e.g. madrone and oak leaves, conifer needles) or thatch from accumulation of dead or living grass leaves, tillers, or racemes, individuals appear to alter their growth form by producing many small bulb leaves as opposed to adult sized leaves (Pacific Crest Consulting 2010, Siskiyou BioSurvey LLC 2013). This maybe a response to a lack of sunlight and younger plants may be unable to survive. The suppression of natural, periodic fires has likely allowed this duff or thatch layer to accumulate. The magnitude of this threat is unknown because no standardized measurement of duff or thatch accumulation or leaf mortality has been incorporated into the monitoring protocol. However, the threat it is considered to be widespread due to suppression activities across southern Oregon. (USFWS, 2016)

Stressor: Small population size (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: The number of flowering plants is our best gage to determine plant population status, because in the field, the flowers are the only distinguishable characteristic of the plant. A flowering plant count however, is at best a rough estimation of a plant population size. The majority of *Fritillaria gentneri* populations have less than two flowering plants. In the last five years, between 0 and 2 flowering plants were observed across more than half of 58 monitoring sites (Siskiyou BioSurvey LLC 2013). Patches comprised of few plants are at a much higher risk of decline or extirpation due to demographic or stochastic events compared to larger populations. Diseases, herbivory, natural disturbances, localized accumulation of duff or thatch, unfavorable weather events, successional changes, reproductive failure, and anthropogenic impacts are examples of demographic or stochastic events which can jeopardize small populations. Moreover, because of their size and the clonal nature of *F. gentneri*, these small populations may suffer from a lack of genetic diversity. Genetic uniformity may render populations more vulnerable to pests and diseases. The species also may lack the genetic flexibility to adapt to long-term environmental or climate changes. (USFWS, 2016)

Stressor: Climate change (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: The effects of climate change will likely affect ecological dynamics by altering precipitation and temperature patterns. Evidence of 30 years of warming temperatures at the end of the twentieth century show phenology of organisms, the range and distribution of species, and the composition and dynamics of communities are affected (Walther et al. 2002). Temperature records indicate that Pacific Northwest temperatures increased 0.8° C since 1920 (Littell et al. 2009). Climate change is expected to lead to increased variability in precipitation (McLaughlin et al. 2002), and increased loss of soil moisture due to evaporation and transpiration of water from plants (Field et al. 1999); this may exacerbate effects due to drought. As a consequence, *Fritillaria gentneri* habitat may become more inhospitable given that climate models predict a temperature increase of 1 to 2° C by 2040 with another 3 to 4° C by 2080 and decreased growing season precipitation in the Pacific Northwest (Doppelt et al. 2009). Modest changes in winter warming could result in a greater percentage of flowering plants, if spring precipitation increases (Giles Johnson et al. 2014). However; climate change is expected to lead to increased variability in precipitation, and could result in extended droughts, thus potentially impacting smaller *F. gentneri* populations. (USFWS, 2016)

Recovery

Reclassification Criteria:

1. Each recovery unit shall maintain at least 750 flowering plants (USFWS, 2003)

Recovery Priority Number: 14

Delisting Criteria:

1. Each recovery unit shall maintain at least 1,000 flowering plants. These 1,000 flowering plants should occur in protected *Fritillaria* management areas and should have exhibited net demographic stability or growth for a minimum of 15 years, as determined through at least biennial demographic monitoring. Measurements of population size and structure are based on counts of flowering individuals because non-flowering *Fritillaria* species are not easily distinguished. A population with a count of 1,000 flowering plants would be estimated to range in size from 26,008 to 52,682 individuals altogether. (USFWS, 2003)

Recovery Actions:

- 1. Provide private landowners with information on identification and management of habitat to maintain *Fritillaria gentneri*. Although the primary focus of recovery efforts will lie in the establishment of secure *Fritillaria* management areas, conservation of all extant occurrences, even those in private ownership that only contain a few individuals, remains an elemental goal of this plan. These populations contribute to the overall abundance and distribution of the species and may harbor genetic variability important for conservation and recovery efforts. (USFWS, 2003)
- 2. Establish a minimum of eight *Fritillaria* management areas (allocated among four recovery units as detailed in Objectives and Criteria). The core of recovery efforts for *Fritillaria gentneri* will lie in the establishment of at least eight *Fritillaria* management areas in four recovery units where the species will be secure from all threats identified in Reasons for Listing. The distribution of these *Fritillaria* management areas within the specified recovery units, minimum population size criteria, and other specifications are detailed in the preceding Recovery Strategy, Objectives and Criteria sections. (USFWS, 2003)
- 3. Conduct surveys and research essential to conservation and recovery. The following actions are identified as necessary to increase our knowledge of *Fritillaria gentneri* and assist in developing effective recovery strategies for the species. (USFWS, 2003)
- 4. Develop off-site germplasm banks to maintain reproductive materials. One of the fundamental goals of establishing large *Fritillaria* management areas is to reduce the threat of extirpation by random catastrophic events, such as pest and disease outbreaks, vandalism, intense wildfires, unfavorable climatic events, etc. However, as *Fritillaria gentneri* apparently only rarely produces seeds, and therefore probably lacks a significant seed bank, this species lacks resiliency in the face of catastrophic events. Such events may be crippling and irreversible for a plant species that does not produce seeds as a rule. Not only are seedproducing plants capable of forming natural soil seed banks, but their seeds can also be used to develop artificial (off-site) seed banks, thus providing additional security against threats in their environment. (USFWS, 2003)
- 5. Review and revise recovery plan as needed, based on accumulation of new data. As new information about *Fritillaria gentneri* becomes available through additional surveys, research, and management experience, the objectives, criteria, and recovery actions in this recovery plan should be reviewed and revised, as necessary. Of specific importance may be evaluations of recovery unit delineations, allocation of *Fritillaria* management areas within recovery units, the size and structure criteria of *Fritillaria* management areas, and future research and management needs. (USFWS, 2003)
- All government entities — The Service should develop a single or multiple conservation agreements with appropriate parties to formally establish *Fritillaria* management areas at the largest population centers, to enable the best opportunity for recovery. (USFWS, 2016)

- City of Jacksonville Cemetery Site and Jacksonville Woodlands — The Service should coordinate with the ODA and the City of Jacksonville to: 1) Revise the vegetation management plan at the Jacksonville Cemetery, to ensure that habitat restoration and non-native, invasive plants are controlled or eradicated. 2) Consider establishing additional *Fritillaria gentneri* populations or sites on city property, as feasible and appropriate. (USFWS, 2016)
- Oregon Department of Transportation (ODOT) — The Service will continue to coordinate with ODOT to: 1) Define management activities for *Fritillaria gentneri* that will ensure the Grants Pass site to support a recovery level population (e.g., population of at least 100 plants). Determine if recent restoration efforts have been successful for this management area. Future restoration and recovery efforts will be implemented under the ODOT Routine Maintenance Habitat Conservation Plan, which is in development. (USFWS, 2016)
- Oregon Parks and Recreation Department (OPRD) — The Service and ODA should continue coordination with OPRD to: 1) To continue reintroduction of *Fritillaria gentneri* at Rogue River State Park. (USFWS, 2016)
- Medford District, Bureau of Land Management (BLM) and Rogue River-Siskiyou National Forest (RRNF) — The Service should coordinate with BLM and RRNF to: 1) Expand surveys on unsurveyed, suitable habitat for *Fritillaria gentneri* occurrences. 2) Identify sites supporting declining populations and prioritize them based on vegetation management needs. 3) Continue long-term *Fritillaria gentneri* monitoring. 4) Determine management strategies most appropriate to support large *Fritillaria gentneri* populations (e.g., manual or mechanical control, controlled burns, grazing, developing habitat corridors) and the estimated treatment interval necessary to maintain the population at a recovery level size. 5) Continue to expand *Fritillaria gentneri* reintroduction and augmentation efforts. (USFWS, 2016)
- California Department of Fish and Wildlife (CDFW) — The Service should coordinate with CDFW to: 1) Define management activities for *Fritillaria gentneri* that will allow the Brushy Gulch sites to support a recovery level population. If necessary, habitat within these management areas could be opened up by mechanical brush treatment, allowing the present population to expand. (USFWS, 2016)
- USFWS, Roseburg Field Office — The Service will perform the following, as funding and staffing allow: 1) Review recovery criteria, as appropriate, based on new distribution, threats, population, demography, breeding system, and propagation information, and adjust recovery criteria to reflect best available information. 2) Evaluate new occurrence information and update the recovery units accordingly. 3) Fund research to better estimate *Fritillaria gentneri* population size using sampled molecular data from non-flowering juvenile plants. 4) In cooperation with our partners, fund expansion of *Fritillaria gentneri* recovery activities such as propagation, population augmentation, reintroduction, monitoring, and habitat management. 5) Continue to encourage studies that examine the effects of global climate change on this species and how it could affect species dispersal using bulb translocation. 6) Once *Fritillaria gentneri* seeds can be produced more readily, investigate the success of seeding for augmentation and reintroduction. (USFWS, 2016)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Recommend delisting Gentner's fritillary. • Develop a post-delisting monitoring plan (USFWS, 2022).

References

USFWS 2016. STATUS OF THE SPECIES Gentner's Fritillary (*Fritillaria gentneri*). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016

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

USFWS. 2016. STATUS OF THE SPECIES Gentner's Fritillary (*Fritillaria gentneri*). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016

USFWS 2016. STATUS OF THE SPECIES Gentner's Fritillary (*Fritillaria gentneri*). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016. USFWS. 2022. Species status assessment report for *Fritillaria gentneri* (Gentner's fritillary). Version 1.0. U.S. Fish and Wildlife Service Pacific Region, Portland, Oregon.. 105 pp.

USFWS. 2016. *Fritillaria genineri* (Gentner's fritillary) Endangered

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Jacksonville Ecological Services Field Office. 48 pp. January 25, 2016.
https://ecos.fws.gov/docs/five_year_review/doc4759.pdf

USFWS. 2003. Recovery Plan for *Fritillaria gentneri* (Gentner's fritillary). U.S. Fish and Wildlife Service, Portland, Oregon. 89 pp. https://ecos.fws.gov/docs/recovery_plan/030828.pdf

USFWS. 2022. Species status assessment report for *Fritillaria gentneri* (Gentner's fritillary). Version 1.0. U.S. Fish and Wildlife Service Pacific Region, Portland, Oregon.. 105 pp.

SPECIES ACCOUNT: *Harperocallis flava* (Harper's beauty)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/1/1979; Southeast Region (R4)

Physical Description

Harperocallis flava is a perennial herb that increases by shallow, slender, swollen noded rhizomes. The leaves are basal, linear, equitant, 5-21 centimeters long and 2-3 millimeters wide. The stems are short and usually sheathed at a base of fibrous old leaf bases. A single flower is borne on a stalk much longer than the leaves, and has 2-3 widely separated bracteal leaves persisting in a cup. Tepals 6, (calyx and corolla appearing alike), persisting as in rushes, spreading in anthesis, erect in fruit, oblanceolate, acute, 9-15 millimeters long, yellowish above, greenish beneath, with several lengthwise nerves. Stamens 6, arising around the base of the ovary, ascending-erect, the filaments slender, tapering apically, 6-7 millimeters long, the anthers oblong, attached at the base, 2-3 millimeters long, with a short, peglike apex. The ovary is ovoid, 3-lobed, 7.0-8.5 millimeters long, minutely and copiously bumpy, the lobes each narrowing into separate, button-like stigmas. The fruit is surrounded by erect, greenish, purple-margined tepals, ellipsoidal, 8-9 millimeters long, 3-chambered, with a warty surface. Seeds are narrowly fusiform, pale yellow, 2-3 millimeters long, straight or curved and often twisted. (McDaniel, 1968; Kral, 1982). (USFWS, 1983)

Taxonomy

Initially, *H. flava* was described as a monotypic genus (McDaniel 1968). But on the basis of molecular and morphological evidence, it was expanded to include ten species native to the Guianas and the northern Andes formerly placed in the genus *Isidrogalvia* (Campbell and Dorr 2013). The Angiosperm Phylogeny Group (APG) revised and updated the classification for the families of the flowering plants (APG II 2003). The APG II classification system assigned many of the Liliaceae (family that Harper's beauty belonged prior to the new taxonomic classification) to different families based on genetic relationships; however, many scientists still use Liliaceae s.l. rather than the APG system. The APG II transferred Harper's beauty to the Tofieldiaceae, a family now composed of four genera and embedded in the clade of Alismatales (Tamura et al. 2004). (USFWS, 2016).

Historical Range

When first discovered in 1965, this species was known only from only one population in Franklin County, Florida. Populations were later found in Liberty County (USFWS, 1983).

Current Range

Occurs in Franklin, Liberty and Bay Counties, Florida (USFWS, 2016)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual, vegetative (USFWS, 2016)

Breeding Season

Adult: April - May (NatureServe, 2015)

Reproduction Narrative

Adult: Blooms in mid April to early May, and fruits in July (Walker and Silletti 2005). It is thought that roadside populations of this species are dispersed by water and by lawn mowers (Godt et al. 1997). Walker and Silletti (2005) found that recruitment was very low and mortality was high during their 3 year study (NatureServe, 2015). It reproduces both sexually via seeds and asexually via rhizomes (USFWS, 2016).

Habitat Type

Adult: Terrestrial (NatureServe, 2015); wetland (USFWS, 2016)

Habitat Vegetation or Surface Water Classification

Adult: Long-leaf pine ecosystem, bogs (NatureServe, 2015); wet prairie (USFWS, 2016)

Dependencies on Specific Environmental Elements

Adult: Full sun (NatureServe, 2015); 2 - 4 year fire intervals (USFWS, 2016)

Geographic or Habitat Restraints or Barriers

Adult: Dense vegetation, plantations, developed areas (NatureServe, 2015)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Habitat Narrative

Adult: Occurring in the long-leaf pine ecosystem, this species occurs in acidic boggy areas in full sun with soils high in sand and peat. Most occurrences are found in open seepage bogs dominated by a suite of herbaceous species and lacking woody vegetation. Sometimes the species is found growing at the base of woody evergreen shrubs with few herbaceous species (Walker and Silletti 2005). *Harperocallis flava* grows most prolifically in places where some degree of soil disturbance has prevented a grass mat from forming. There are several populations that were found in the 1990s in more 'natural' settings due to prescribed burns and increased search efforts (Walker and Sillettii 2005). Presettlement habitat was probably open bogs surrounded by buckwheat tree (*Cliftonia monophylla*) and pond pine (*Pinus serotina*), and bog-flatwood ecotones where periodic fire prevented woody succession. The environmental specificity of this species is very narrow. Separation barriers for this species include dense shrub thickets, pine plantations, fire-suppressed flatwoods, developed areas (NatureServe, 2015). Harper's beauty occurs on gentle slopes, seepage savannas between pinelands, and cypress swamps to open roadside depressions. Typically, this species occurs in wet prairies, in transitions to wetter shrub zones and roadside ditches. Wet prairie occurs on low, relatively flat, poorly drained terrain of the coastal plain, which is seasonally inundated or saturated for 50 to 100 days each year and burns every 2 to 4 years (Jenkins et al. 2007). Frequent (every 2-4 years) prescribed burnings are needed to maintain optimal habitat for *H. flava* populations (USFWS, 2016).

Dispersal/Migration**Dispersal**

Adult: Low (inferred from NatureServe, 2015)

Dispersal/Migration Narrative

Adult: It is thought that roadside populations of this species are dispersed by water and by lawn mowers (Godt et al. 1997) (NatureServe, 2015).

Population Information and Trends**Population Trends:**

Decline of <70% to relatively stable (NatureServe, 2015)

Species Trends:

Unknown (USFWS, 2016)

Number of Populations:

27 (USFWS, 2022)

Population Size:

~7,600 (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Studies could detect no genetic variability in this species (Godt et al. (1997). In addition, the study by Walker and Silletti (2005) found that recruitment was very low and mortality was high during their 3 year study. While the long term trend is not known, it is suspected that there has been decline due to habitat loss. The long-term population trend is a decline of <70% to relatively stable. Populations in the Walker and Silletti (2005) study make up at least 1,800 (and probably more) ramets given that they set out to sample at least 300 plants from each of 6 sites. If all populations of this species were healthy, in natural settings and repeatedly producing the maximum number of ramets mentioned here, the total number of genetically distinct individuals might be around 7,600, based on a rough calculation from these studies. With this said though, several studies have reported sharp declines during droughts, and individuals of this species are known to exhibit traits that indicate genetic instability (Godt et al. 1996). Finally, total population number does not seem to be the best indicator of this species' conservation priority, since it might lead one to think that the species is of lower conservation concern than it really is. One important consideration is that a genetic study, done before the Bays Co. population was discovered, found that there is no genetic diversity among populations (Godt et al. 1997). Given the very small distribution, the decline in the recent past, the genetic constraints and the anthropogenic threats, this species' future is precarious (NatureServe, 2015). The species status is unknown; data on population trends or habitat conditions across the whole range of the species is lacking. Currently, there are 28 EOs with 23 of those populations being extant (USFWS, 2016). Currently there are 29 FNAI EOs documented in these three

counties with the majority located in Liberty County (Fig. 1, Table 1; FNAI 2021). Since two EOs are presumed extirpated (Fig. 1), only 27 FNAI EOs are considered extant (FNAI 2021) with the status of Bay County EO unknown. (USFWS, 2022)

Threats and Stressors

Stressor: Industrial forestry practices and residential/commercial development (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: The timber industry in North Florida became well established in the 1850s (FNAI 2005). Privately owned companies farm trees for timber and byproducts by mechanically preparing the site for planting, planting seedlings, and mechanically harvesting the trees typically by thinning and later clear cutting the site; then the process is repeated. These activities may reduce flora diversity, introduce exotic species and result in local extinction of native forest flora (Newmaster et al. 2007). The St. Joe Timberland Company (Timberland Company) is currently the largest timber company in the eastern region of the Panhandle with over 450,000 acres in silviculture, plus several other timber companies operate in the Panhandle. The timber industry is currently thriving and there is no indication that it will decline in the foreseeable future. In 2013, the Timberland Company sold more than 380,000 acres of its land to AgReserves, Inc., a tax-paying company owned by the Mormon Church. The land sold, which will maintain timber and agriculture uses, included lands in Bay, Calhoun, Franklin, Gadsden, Gulf, Jefferson, Leon, Liberty and Wakulla counties. The species now occurs on AgReserves, Inc.-owned property in Bay County, Florida, and this property may be utilized for timber and agriculture production. Therefore, tree farming remains a threat to this species. In addition to being one of the largest private landowners in northwest Florida, the Timberland Company is also one of the largest real estate operating companies in the Southeast. This company develops both residential and commercial properties along roadways and near or within business districts in the region. Urbanized land in Florida, statewide, is projected to double by 2060 along with doubling of the population to 36 million. Because of lack of access and survey effort, there may be sites within these silvicultural lands that could support this species but have not yet been identified. Given the human population increase and proximity of these lands to established population centers in Bay County, residential or commercial development is a threat. (USFWS, 2016)

Stressor: Crayfish activity (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Walker and Silletti (2005) observed that crayfish mounds and chimneys buried many ramets. At the end of the three-year demographic study, ramet mortality was significantly higher in bog sites (22.2%) than in shrub sites (3.6%). Therefore, crayfish activity may pose a threat to the species (USFWS, 2016).

Stressor: Climate change (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: According to the Intergovernmental Panel on Climate Change Report (IPCC 2013), warming of the earth's climate is "unequivocal," as is evident from observations of increases in average global air and ocean temperatures, increases in concentration of greenhouse gases, widespread melting of snow and ice, and rising sea level. Being endemic to Florida, *H. flava* has a restricted range; therefore it is potentially at risk, specifically since Florida is one of the areas most vulnerable to the consequences of climate change. Using the NOAA Sea Level Rise (SLR) and Coastal Flooding Impacts Viewer (<https://coast.noaa.gov/slr/>), the projections indicated potential impact to both known *H. flava* EOs in Franklin County by intrusion of saltwater beginning at one foot SLR (USFWS, 2016).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Section 7(b)(4) and 7(b)(2) of the Act generally do not apply to listed plants species. However, limited protection of listed plants from take is provided to the extent that the Act prohibits the removal and reduction to possession of federally listed threatened and endangered plants or the malicious damage of such plants on areas under federal jurisdiction, or the destruction of endangered plants on non-federal areas in violation of state law or regulations or in the course of any violation of a state criminal trespass law. While the Act requires federal agencies to carry out programs for the conservation of endangered and threatened species, no such programs are stipulated for private landowners. The Act does not provide for protection of plants on private lands as long as the activity is permissible under state/local laws. The State requires permission of private landowners for collecting of state-listed plants from their property. *Harperocallis flava* is protected under Florida State Law, chapter 85-426, which includes preventions of taking, transport, and the sale of the plants listed under the State Law. The rule Chap. 5B-40, Florida Administrative Code, contains the "Regulated Plant Index" (5B-40.0055) and lists endangered, threatened, and commercially exploited plant species for Florida; defines the categories; lists instances where permits may be issued; and describes penalties for violations. Currently, Federal, State, and County regulations do not provide adequate protection. (USFWS, 2016)

Stressor: Fire suppression (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Suppression of fire continues to threaten the pineland and savanna's flora as fire is an important factor in the maintenance of flatwoods (Abrahamson and Hartnett 1990). Fire influences community structure and composition (Abrahamson and Hartnett 1990), and with insufficient frequency in longleaf pine communities, a woody midstory quickly develops (Glitzenstein et al. 1995), negatively affecting the understory diversity. Several studies have shown that frequent prescribed fire regimes are important for maintenance of flatwoods diversity (Hiers et al. 2007). Lack of fire, and subsequent growth of shrubs, and encroachment of swamp titi and saplings in the understory, inhibits this species emergence (Negrón-Ortiz, 2008, pers. observ.; FNAI 2008), reducing its abundance in areas where it was previously observed in great quantities (FNAI 2008). Furthermore, heavy shrub encroachment reduces the herbaceous ground cover in general, making it more difficult to applied prescribed fire. Therefore, frequent (every 2-4 years) prescribed burnings are needed to maintain optimal habitat for *H. flava*

populations. (USFWS, 2016)

Stressor: Road widening/Infrastructure improvements (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Many *H. flava* plants are found along ANF SR 65. SR 65 is a major north-south corridor through ANF and it was recently improved by repairing or replacing culverts, elevating pavement, and widening travel lanes. While there are no current plans to increase the road capacity from two to four lanes, it remains a likely future scenario as SR 65 is an important hurricane evacuation route from the Gulf Coast. Roadside widening activities using heavy equipment or any soil disturbances to the right-of-way locations negatively impact plants (Kesler and Trusty 2012, unpubl. report). Construction activity may directly kill individual plants or convert habitat to unsuitable space; widening may convert native habitat to managed roadside; and culvert modification may change drainage patterns, which may change seasonal hydrology. Therefore, road widening and new roads continue to pose a threat to the species from habitat loss. (USFWS, 2016)

Recovery

Reclassification Criteria:

1. When five populations have two colonies each or when three populations have three colonies each (USFWS, 1983).

Recovery Priority Number: 8C

Delisting Criteria:

1. When a minimum of five secure wild populations, with a minimum of three colonies each, have been found or established in habitat similar to that of the type locality so as to reestablish colonies away from the roadside. Colony 1-1, the type locality, should be one of these colonies. Criteria regarding minimal percent frequency and cover for each colony needs to be set, but will require prior research. Before a colony can be considered secure it must be protected and managed in such a way as to insure its continued survival. (USFWS, 1983)

Recovery Actions:

- 1. Protect habitat and existing colonies of Harper's beauty. Protecting existing individuals in the colonies and the habitat upon which they depend probably represents the first and best opportunity for assuring survival of Harper's beauty. This will require careful monitoring and management. Efforts should be made to encourage natural regeneration in the current localities, and to determine the habitat factors essential to maintain and expand the species. (USFWS, 1983)
- 2. Conduct searches for new colonies. Since Harper's beauty was reported (1968), it has only been searched for sporadically. There needs to be a thorough systematic effort to search for new colonies of this taxon. Since its habitats are scattered throughout the area, it is possible that other colonies could be found, as additional sites were found by Leonard and Baker in 1982. Initial searches should be concentrated in Liberty and Franklin Counties in Florida. (USFWS, 1983)

- 3. Preserve existing germ plasm. A well developed plan for cultivation will ensure that Harper's beauty does not become extinct. Through the refinement of techniques for mass propagation of vegetative material and the dissemination of this material to the private and public sectors, the program will be greatly enhanced. The establishment of pollen and seed banks is very important to the preservation of this taxon. It should be noted that the cultivation program is secondary to efforts aimed at maintaining and expanding the existing colonies through natural regeneration, but it is potentially valuable, nevertheless. If, by some accidental means, the existing colonies of Harper's beauty are destroyed before the establishment of new colonies, future attempts at reestablishment would require the use of cultivated material. Also, to minimize disturbance to the natural colonies, seed for establishing new and experimental colonies should be obtained from cultivated stock. (USFWS, 1983)
- 4. Establish additional colonies. New colonies need to be established, within the historical range of the species, in order to meet the recovery objective. Many natural bogs occur on Forest Service lands in the vicinity of the present colonies. Some of these sites could be used for establishing new colonies. This would save the cost of acquiring land specifically for this purpose. Monitoring and maintaining the new populations might be easier utilizing staff that is already managing public lands. (USFWS, 1983)
- 5. Monitor and manage colonies to assist and maintain recovery. Since ecosystems are dynamic, populations can be expected to undergo some natural changes. Populations also change in response to human- related causes. Changes due to both nature and man need to be monitored both before and after recovery. Some active management will probably be necessary to insure that the recovery objective can be met. Management techniques used should be based on sound research. (USFWS, 1983)
- 6. Determine appropriate means of public education. The recovery effort should include a positive education program. Brochures and/or interpretive exhibits at Forest Service Ranger Stations or nearby nature centers could be very beneficial in describing the plant in its unique habitat, and in describing the dangers it faces and ways the public can help conserve it. Articles in appropriate magazines and/or newspapers may also be helpful. (USFWS, 1983)
- Location of further populations is essential, as this may lead to the discovery of new genets. This action can include the use of species distribution modeling methods to initially determine potential sites, with subsequent validation or inspection of the sites for plants (USFWS, 2016).
- Finding/identifying compatible genotypes is recommended to increase the likelihood of sexual reproduction (USFWS, 2016).
- In-situ conservation is essential and should aim to protect all populations as the loss of any single population leads to a substantial reduction in the overall genetic diversity. Specifically, Forest Service compartment no. 80 is important to protect because it contains a group of plants with unique genotypes. Additionally, the roadside population is vital to protect and preserve because it is comprised of unique multi-clone assemblages and distinctive genotypes (USFWS, 2016).
- Ex- situ conservation: A bank of seeds and ramets sampled from all known populations should be permanently maintained in nurseries in botanical gardens or other institutions, identified according to the source plant. This material could be used for reintroduction (USFWS, 2016).
- Secure the privately-owned population from Bay County via land acquisition, conservation easement, or by implementing permanent conservation measures between the Service and

- the AgReserves, Inc (USFWS, 2016).
- Continue fostering conservation practices for utility and highway ROWs with the Forest Service, FDOT, and the Service (USFWS, 2016).
 - Since recruitment from seed appeared rare (Kesler and Trusty 2012, unp. report), the following studies are recommended: breeding systems, seed germination and seedling recruitment; the viability of dry-stored seeds, the timing of germination, and whether a persistent seed bank is present (USFWS, 2016).
 - Label the clones identified by the genetic study (USFWS, 2016).
 - Due to the extensive clonality exhibited by this species, the word 'colony' (a term used in the Recovery Plan) should be replaced with 'clone' (USFWS, 2016).
 - Monitoring/censusing: Although a comprehensive census throughout the present distribution, including all the historical locations is needed, it is recommended to set up subplots and monitor both flowering and nonflowering individuals. Given the cryptic nature of this plant when it isn't flowering, the density of surrounding vegetation and the number of locations, monitoring is best recommended a year post-fire (J. Drake, 2016, pers. comm.). (USFWS, 2016).
 - The effect of fire on clonality (including winter vs. growing season prescribed fire, fire frequency, intensity, duration, and timing) should be further investigated and monitored (USFWS, 2016).
 - The recovery plan should be updated to define objective measurable criteria and better address the five factors (USFWS, 2016).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTION Immediate actions 1. Location of further populations is essential, as this may lead to the discovery of new genets. This action can include the use of species distribution modeling methods to initially determine potential sites, with subsequent validation or inspection of the sites for plants. 2. Private land conservation. Seek partnership with the AgReserves, Inc to: • conduct surveys and document the status of *H. flava* habitat and population in Bay County. • develop conservation goals and best management practices, and protection strategies (land acquisition, conservation easement, or implement permanent conservation measures). 3. Survey and document the crayfish activities on *H. flava* to update the observations of Walker and Silletti (2005) and assess whether activities pose a threat. 4. In-situ conservation is essential and should aim to protect all populations as the loss of any single population leads to a substantial reduction in the overall genetic diversity. Specifically, USFS compartment no. 80 is important to protect because it contains a group of plants with unique genotypes. Additionally, the roadside plants are vital to protect and preserve because it is comprised of unique multi-clone assemblages and distinctive genotypes. 5. Ex- situ conservation: A bank of seeds and ramets sampled from all known populations should be permanently maintained in nurseries in botanical gardens or other institutions, identified according to the source plant. This material could be used for reintroduction (Walker 2015, Service 2016). 6. Continue fostering conservation practices for utility and highway ROWs with the Forest Service, FDOT, and the Service. 7. Since recruitment from seed appeared rare (Kesler and Trusty 2012), the following studies are recommended: • breeding systems, seed germination and seedling recruitment; the viability of drystored seeds, the timing of germination, and whether a persistent seed bank is present. Partially completed by Gardner (2021). • determine the impact of Orthopterans on *H. flava* reproductive success (Fig. 3) • seeds can survive several storage conditions: from non-dried seeds stored at ambient laboratory conditions, to long-dried seeds stored at -80 °C for up to one year. Gardner (2021) further suggested: a. additional

investigations to describe *H. flava*'s viability of dry-stored seeds since preliminary studies suggest that intermediate storage behavior such as freeze sensitivity results in severe loss of seed viability after two years at -18 °C. Note: The seed stored at Bok Gardens can be used as part of this investigation. The Bok Gardens conducted seed experiments from collections done in 2006 and 2007; only seeds collected in 2007 germinated. No additional work was pursued in 2008 or subsequent years (C. Peterson, Bok Gardens, pers. comm., 2021). • find/identify compatible genotypes to increase the likelihood of sexual reproduction. 8. Continue best management practices within the Apalachicola National Forest (ANF) 2011-2020: Prescribed burn has averaged 67,896 acres / year within the ANF and 89,436 acres / year when personnel assist on adjacent public lands (e.g., Tate's Hell SF and Lake Talquin SF) (J. Drake, USFS ecologist, 09/21/2021). In addition to prescribed fire, the ANF also regularly implements vegetation management activities (e.g., timber thinning, groundcover restoration) with the primary goal of restoring native longleaf pine dominated ecosystems which provide habitat for many rare species (J. Drake, USFS ecologist, 09/21/2021) (USFWS, 2022).

References

USFWS. 2016. *Harperocallis flava* (Harper's beauty)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Panama City Field Office. 24 pp. February 23, 2016. https://ecos.fws.gov/docs/five_year_review/doc4762.pdf

USFWS, 1983. Harper's Beauty Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 32 pp.

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

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Panama City Field Office. 24 pp. February 23, 2016. https://ecos.fws.gov/docs/five_year_review/doc4762.pdf USFWS. 2022. Harper's beauty (*Harperocallis flava*) 5-Year Review: Summary and Evaluation. USFWS. South Atlantic–Gulf and Mississippi Basin Regions Florida Ecological Services Field Office Panama City, Florida. 19 pp.

USFWS 2016. *Harperocallis flava* Harper's beauty 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region. Panama City Field Office, Panama City, Florida.

USFWS. 2022. Harper's beauty (*Harperocallis flava*) 5-Year Review: Summary and Evaluation. USFWS. South Atlantic–Gulf and Mississippi Basin Regions Florida Ecological Services Field Office Panama City, Florida. 19 pp.

SPECIES ACCOUNT: *Helonias bullata* (Swamp pink)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/11/1988; Northeast Region (R5)

Physical Description

A smooth perennial herb with thick, stocky rhizomes. Its leaves, which form a basal rosette, are evergreen, oblong—spatulate or oblanceolate, parallel—veined, 0.9-2.5 dm long, 2-4 cm wide, acute, and attenuated at the base. A stout hollow stem arises from the rosette and may grow from a height of 2-9 dm at the time of flowering to 1.5 m at the time of seed maturation. The sparsely bracteate flower stalk is 1-3 dm high when flowering and up to 6 dm when in fruit. The stalk is terminated by a simple and short, dense, bractless, 3—8 cm long raceme. The rootstock is stout with many fibrous roots. The inflorescence consists of 30—50 fragrant flowers (Sutter 1982, 1984); individual flowers are about 1 cm wide. Pedicels are very short at first, elongating to 4-8 mm. The perianth is composed of six spatulate-oblong, pink to lavender segments that are 5-9 mm long and 1-2 mm wide. As the inflorescence elongates, the perianth persists and retains a pink color interfused with green. The fruit capsule is 3-lobed, papery, 3-5 mm long and 8- 10 mm wide, with an inverted heart shape and consisting of many ovules. The ovule opens into six lobes releasing linear-shaped seeds that are 5 mm long with appendages at both ends (Johnson undated). Mature seeds were not described by Johnson or Sutter. During the winter months, the leaves of *Helonias* lie flat or slightly raised from the ground, and are often hidden by fallen leaf litter. The flowerhead of the next season is visible, appearing like a large button in the center of the rosette. Leaves often turn a reddish-brown color over the winter; new, bright green leaves appear in spring. Plants bloom as early as March and often last until May, while seed production occurs in June. Typically small at the time of plant flowering, leaves may increase in length to 4 dm or more as the season progresses. (USFWS, 1991)

Taxonomy

Taxonomic authorities have reassigned swamp pink to a different family in the Order Liliales. Starting with the first version in 1998 (APG 1998), and continuing through the current (third) version (APG 2009; Stevens 2012), the Angiosperm Phylogeny Group (APG) has recognized the Family Melanthiaceae (Order Liliales). Within the Melanthiaceae, Stevens (2012) recognizes five tribes including Helionadeae (i.e., Heloniadeae, with Helonieae treated as a synonym by Zomlefer et al. [2001])(USFWS, 2014). - Swamp pink (*Helonias bullata* L.) was first collected by Swedish naturalist Peter Kalm near Philadelphia -- most likely around Pennsneck, New Jersey -- in the mid-1700s (Brown 1910). Kalm's specimens were submitted to Linnaeus, who described the species in the first edition of *Species Plantarum* as a monotypic genus in the Liliaceae (Lily) family (U.S. Fish and Wildlife Service 1988). (USFWS, 1991)

Historical Range

Historically occurred in eight states (New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia). (USFWS, 2014)

Current Range

In 2001, extant populations were documented in seven states: New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia. (USFWS, 2014)

Critical Habitat Designated

No;

Life History**Food/Nutrient Resources****Reproductive Strategy**

Adult: Asexual: vegetative; sexual: self-pollination, cross-pollination (NatureServe, 2015)

Lifespan

Adult: 2+ years (NatureServe, 2015)

Breeding Season

Adult: April - June (NatureServe, 2015)

Key Resources Needed for Breeding

Adult: Possibly insect pollinators (USFWS, 1991)

Reproduction Narrative

Adult: Blooms from early April or early May through mid-June. It is a perennial species. Reproduces sexually and asexually; reproduces vegetatively via rhizomes forming clusters of closely spaced rosettes, and also produces prolific seed following flowering (although very few of the plants in a population typically produce flowers in a given year) (Sutter 1984 cited in CPC 2008, USFWS Swamp Pink Recovery Plan Technical Draft 1990). Highly self-compatible (Sutter 1984 cited in CPC 2008), although the rate of selfing vs. outcrossing in nature appears to vary widely; of fifteen natural populations sampled in a genetic study, estimates suggested that seven of the populations were highly outcrossing, while several other populations had much lower outcrossing estimates (Godt et al. 1995). Seeds are viable for only a few weeks, so the species does not have a seed bank (Godt et al. 1995). A low incidence of flowering, limited seed dispersal, and poor seedling establishment combine to make colonization of new sites via reproduction from seed rare for this species (Godt et al. 1995, USFWS 2007) (NatureServe, 2015). Beetles, black flies, and a variety of other insects have been observed at Helonias flowers (USFWS, 1991).

Habitat Type

Adult: Wetlands (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Atlantic white cedar swamps, headwater seepage wetlands, red maple swamps, mixed hardwood/evergreen swamps, (rarely) black spruce-tamarack (*Picea mariana*-*Larix laricina*) bogs, Blue Ridge seepage swamps (mountain bogs) (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Water depth 5.0 - 9.9 cm (USFWS, 2014)

Spatial Arrangements of the Population

Adult: Clumped (USFWS, 1991)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Restricted to forested wetlands that are groundwater influenced and are perennially water-saturated with a low frequency of inundation. Sutter (1982) described these as sites where the water table is at or very near the surface and is stable, fluctuating only slightly during spring and summer. These habitats include emergent portions of hummocks in and along stream channels in Atlantic white cedar (*Chamaecyparis thyoides*) swamps, headwater seepage wetlands, red maple (*Acer rubrum*) swamps, mixed hardwood/evergreen swamps, and (rarely) black spruce-tamarack (*Picea mariana*-*Larix laricina*) bogs. In Georgia, the species is found in coldwater Blue Ridge seepage swamps (mountain bogs) with purple pitcher plant (*Sarracenia purpurea*), red maple, mountain laurel (*Kalmia latifolia*), Carolina sheep laurel (*K. caroliniana*), rosebay rhododendron (*Rhododendron maximum*), and thickets of tag alder (*Alnus serrulata*) and peat moss (*Sphagnum*). The species appears to be somewhat shade tolerant and to need enough canopy to minimize competition with other more aggressive species and herbivory by deer. It is often found at stream sources. The specific wetland habitat required by this species is easily degraded through both direct and secondary disturbances; among the wetland types it inhabits, some such as sphagnum bogs and Atlantic white cedar swamps are particularly fragile. The environmental specificity is narrow; it is adapted to stable habitats with a number of specialized conditions (e.g., low light, limited nutrients, and saturated soils), this species appears to compete poorly when change in one or more habitat parameters creates an opportunity for the establishment of other species (USFWS 2007) (NatureServe, 2015). Laidig et al. (2009) found that swamp pink clusters, composed of groups of individual plants, were typically associated with the emergent portions of hummocks in and along the stream channels. The greatest total cluster area was associated with water levels between 5.0 and 9.9 cm, which may be the optimal water-level range for swamp pink (USFWS, 2014). There appears to be a strong correlation between the presence of conifer tree species (e.g., pitch pine, Atlantic white cedar, American larch, black spruce, and red spruce) and the occurrence of *Helonias*. Clumping may be due to clonal reproduction and limited seed dispersal (USFWS, 1991).

Dispersal/Migration**Dispersal**

Adult: Typically low, possibly high with water dispersal (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Primary seed dispersal takes place by gravity and wind, which probably carries seeds less than 40 cm (Godt et al. 1995). Secondary seed dispersal by ants and water has been experimentally verified (Peterson 1992 cited in USFWS 2007). Seeds possess eliasomes (lipid-rich ridges of soft tissue) that foster dispersal by ants. Seeds can also float for days, which could facilitate long-distance downstream dispersal by water (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 30-50% (NatureServe, 2015)

Species Trends:

10 - 50% decline (NatureServe, 2015)

Number of Populations:

235 EOs (USFWS, 2021)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

The total number of known extant occurrences of swamp pink (235 in 2020) has decreased for the first time since listing (from 249 in 2011), though the extent of the species' distribution has not changed appreciably. The number of known extant occurrences of swamp pink in 2020 is almost double the number of known extant occurrences in 1991 (123 occurrences) and has increased the species' representation and redundancy since ESA listing. There are 114 extant swamp pink occurrences (49% of total extant occurrences) located at least partially on protected lands, which is more than a three-fold increase compared to the number of known occurrences at least partially protected in 1991 (approximately 35). Of the 114 occurrences that are at least partially protected, 38 are robust A- or B- ranked occurrences that are well distributed across the species' range. However, a significant number of swamp pink occurrences throughout the range, including some occurrences located at least partially on protected land, are clearly declining. In most cases, the declines are gradual and may only become evident over long periods of time, which affords some time for intervention. Cryopreservation of swamp pink seeds has been demonstrated to be possible for the first time and long-term storage of seeds from one swamp pink population was initiated at the Atlanta Botanical Garden (Perullo et al. 2015). Additional collections of marginal and highly imperiled genotypes will be needed to preserve the adaptive capacity of the species long-term. (USFWS, 2021)

Threats and Stressors

Stressor: Habitat degradation from development (USFWS, 1991)

Exposure:

Response:

Consequence:

Narrative: Over the years, cumulative habitat destruction resulting from development projects, draining and filling of wetlands, and timbering and clearing activities has significantly reduced the amount of available area for Helonias. As one example, many Southern Appalachian bogs have been destroyed by drainage and development, particularly for industrial sites and recreational resorts (e.g., golf courses) -- once destroyed, these bogs are impossible to re-create. With particular regard to the Pink Beds population in North Carolina, this area is currently threatened by plans to expand recreational development in the National Forest; further, one colony in this vicinity has already been seriously degraded by construction of trails and runoff from nearby roads. - With the enactment of the Federal Clean Water Act, along with state wetland laws and endangered species protection measures, direct habitat loss has been supplanted by secondary

impacts resulting from off-site disturbances as the major threat to Helonias. While some degree of direct habitat damage is still occurring, the destruction of wetlands that support Helonias populations and contain suitable habitat has slowed; however, upstream development continues to accelerate. Although definitive data do not currently exist, it is suspected that many extant and seemingly vigorous New Jersey populations are in the process of a slow decline due to, in several instances, the secondary impacts of development of areas surrounding these populations combined with the lack of adequate buffers. (USFWS, 1991)

Stressor: Climate change (USFWS, 2008)

Exposure:

Response:

Consequence:

Narrative: In a 1997 assessment of climate change impacts in North America (Watson et al., 1997), the Intergovernmental Panel on Climate Change (IPCC) found that important vulnerabilities of water resources to potential scenarios of climate change involve changes in runoff and stream flow regimes, reductions in water quality associated with changes in runoff, and human demands for water supplies. Specific findings of this assessment relevant to swamp pink include: • Seasonal and annual runoff may change over large regions as a result of changes in precipitation or evapotranspiration. • Seasonal patterns in the hydrology of mid- and high-latitude regions could be altered substantially, with runoff and stream flows generally increasing in winter and declining in summer. • Altered precipitation and temperature regimes will affect the seasonal pattern and variability of water levels of wetlands, thereby affecting their functioning including flood protection, carbon storage, water cleansing, and waterfowl/wildlife habitat. • Increases in the frequency or magnitude of extreme hydrological events could result in water quality deterioration and water management problems. • Increases in competition for limited water under a warmer climate could lead to supply shortfalls and water-quality problems, particularly in regions experiencing declines in runoff. (USFWS, 2008)

Stressor: Collection (USFWS, 1991)

Exposure:

Response:

Consequence:

Narrative: Plant collection remains a continuing problem. Traditionally, collection of this wildflower has been a common practice of both amateur and professional gardeners, scientific and other collectors (due to its unusual appearance), and curiosity seekers (U.S. Fish and Wildlife Service 1988). The plant is very conspicuous, particularly during the flowering season because it frequently blooms before other wildflowers and before growth of other herbaceous vegetation. In The Pine Barrens, John McPhee (1967) noted that "Pineys" collected swamp pink for sale in the cities. Wildflower and gardening field guides often point to Helonias as a beautiful plant, suitable for home gardens. In addition to collection, foot traffic presents a problem at some sites. By altering hydrologic conditions, soil compaction probably represents a greater threat to the species than trampling of plants. This problem can be somewhat offset by constructing boardwalks; at a site in the George Washington National Forest, a boardwalk was constructed by the Forest Service to alleviate the trampling pressure on a site located there (Robert Glasgow, George Washington National Forest, pers. comm.). However, there is also a concentration of use along boardwalks that may lead to increased collection. (USFWS, 1991)

Stressor: White-tailed deer (USFWS, 2014)

Exposure:**Response:****Consequence:**

Narrative: Many field biologists report that herbivory pressure on swamp pink from white-tailed deer (*Odocoileus virginianus*) is increasing. Observations from recent surveys in Delaware suggest that three populations may have been extirpated due to deer eating the plants (McAvoy 2011). Deer are a major threat in Camden County, and to a lesser extent also in Salem County, New Jersey (Hogan pers. comm. 2011). Based on work at three south Jersey populations, Dodds (pers. comm. 2011) concludes that the contribution of deer predation to the decline of the species may be much for substantial than previously believed. Kunz (pers. comm. 2011) considers deer browse one of the primary threats to swamp pink in New Jersey (USFWS, 2014).

Stressor: Beaver activity (USFWS, 2014)

Exposure:**Response:****Consequence:**

Narrative: Many field biologists report that hydrologic impacts on swamp pink from beaver (*Castor canadensis*) activity are increasing. During 2011 surveys, Brown et al. (2012) found two of nine swamp colonies impacted by beaver on Fort A.P. Hill, Virginia. McAvoy (pers. comm. 2011) finds that the primary threat to swamp pink populations and habitat in Delaware appears to be from beaver activity, i.e., dam creation and subsequent flooding. Laidig (pers. comm. 2011) considers beavers one of the primary short-term threats to swamp pink populations in the New Jersey Pinelands (USFWS, 2014).

Stressor: Encroachment of woody vegetation (USFWS, 2014)

Exposure:**Response:****Consequence:**

Narrative: Several sites in the southern Appalachians are considered threatened by the encroachment of woody vegetation. Radcliff (pers. comm. 2011) considers this a primary threat in Georgia. Specifically, it is believed that a lack of disturbance mechanisms is leading to encroachment of woody vegetation in southern Appalachian bogs, which in turn is leading to decreased flowering and recruitment in rare plant species like swamp pink (Wells pers. comm. 2011) (USFWS, 2014).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2008)

Exposure:**Response:****Consequence:**

Narrative: Regulatory mechanisms in New Jersey have improved but are still inadequate to protect swamp pink from its primary threat of gradual habitat degradation from development of surrounding uplands. Further protections for swamp pink that may be afforded by proposed regulatory changes in New Jersey will be considered during the next 5-year review. In other states, the primary protection for swamp pink, especially on private lands, is through consultation on Section 404 wetland permits under Section 7 of the ESA. This Federal regulatory mechanism offers limited protection to swamp pink (e.g., does not guarantee buffers or protection of off-site plants), and its effectiveness may be decreasing due to new limits on Federal jurisdiction over wetlands from recent court decisions. - No State laws prohibit the

collection or destruction of Federal- or State-listed plants on private lands with permission of the landowner, although some restrict possession, commercial trade, or collection of State-listed plants from public land. Although it offers no special protections for State-listed plants, New Jersey's FWPA regulates "destruction of plant life which would alter the existing pattern of vegetation" within freshwater wetlands. - Outside of New Jersey, State laws do not prohibit destruction of swamp pink or its habitat incidental to an otherwise lawful activity. In New Jersey, prohibition against such "incidental take" is afforded to State-listed plants in certain geographic areas (e.g., Highlands, Pinelands, Coastal Zone). However, over 60 percent of New Jersey's swamp pink occurrences are outside these areas and are afforded incidental take protection under the FWPA solely due to the species' status as a Federally listed species. (USFWS, 2008)

Stressor: Agriculture (USFWS, 1991)

Exposure:

Response:

Consequence:

Narrative: Agriculture has contributed to the loss and degradation of suitable habitat through (1) off-site water withdrawal for irrigation or crop production, (2) drainage of wetlands for crop production, (3) conversion of wetlands for agricultural uses, e.g., cranberry production), and (4) degradation of water quality by the influx of nutrients, sediment, and chemicals to the water. In the last instance, nutrient loading is thought to contribute to increased rates of succession and colonization by opportunistic species such as common reed (*Phragmites communis*), red maple (*Acer rubrum*), red alder (*Alnus serrulata*), and mountain laurel (*Kalmia latifolia*). (USFWS, 1991)

Stressor: Stream improvement (USFWS, 1991)

Exposure:

Response:

Consequence:

Narrative: Stream improvement for trout has destroyed at least one colony in North Carolina. Other off-site sources of habitat degradation include discharge from sewage treatment plants and other similar operation, as well as watershed perturbations such as siltation resulting from inadequate soil erosion control and modification of the hydrologic regime and/or frequency and duration of "normal" flood events in developed watersheds resulting from random stormwater discharge. Evidence suggests that in developed watersheds, particularly where stormwater is discharged through outfall structures, the frequency and duration of "normal" storm event flooding is altered, leading to adverse impacts to wetlands from increased floodwater elevations, increased flow rates, and increased deposition of floatables and sediments. Helonias appears to be very slow, and perhaps unable, to recolonize openings in suitable habitat, making it susceptible to such perturbations (Virginia Natural Heritage Program 1987). This limited ability to colonize new sites underscores the need to protect existing sites. (USFWS, 1991)

Recovery

Reclassification Criteria:

Not applicable.

Delisting Criteria:

1. Permanent habitat protection is secured for those occurrences that: (a) are ranked as "A" or "B" according to the quality specifications in Appendix B of the Recovery Plan; or (b) are

representative of the species' range-wide distribution; or (c) are representative of habitat or genetic diversity. Habitat will be considered permanently protected when: (1) adequate acreage is secured through acquisition or easement by government agencies or conservation organizations with primary responsibilities for resource protection; (2) sites on public lands are formally designated as protected areas; and (3) preserve designs and/or management stipulations, based on definitive research results, are in place for each site. (USFWS, 1991)

2. Regulatory protection is sufficiently strong at the Federal, state, and/or local levels to ensure continued range-wide conservation of viable populations and their habitat (including an adequate buffer zone) after the protection afforded by the Endangered Species Act is withdrawn. (USFWS, 1991)

3. As necessary, representative genotypes are established and maintained in cultivation at plant breeding facilities. (USFWS, 1991)

Recovery Actions:

- 1. Protect all known Helonias sites. The overriding recovery necessity for Helonias is habitat protection. Measures such as land acquisition and conservation easements will be considered as ways to fully secure the habitat of viable populations. All existing sites will be actively protected by obtaining landowner agreements whenever possible, conducting population monitoring, and enforcing protective regulations. Habitat on public lands should be designated as protected areas or otherwise be exempted from management and development activities that could disturb the species. (USFWS, 1991)
- 2. Characterize extant colonies. Studies to determine genetic variability, population dynamics, and habitat characteristics at several Helonias populations will provide information regarding the species' biology, which will, in turn, aid in conservation efforts. (USFWS, 1991).
- 3. Eliminate, to the fullest extent possible, on- and off-site threats to viable populations. The success of eliminating threats to currently or potentially viable populations will be contingent on the ability of resource experts and land managers to assess the potential for impact of diverse disturbances on populations and to adequately buffer essential habitats from significant threats. (USFWS, 1991)
- 4. Identify and, as needed, implement managment techniques for improving habitat quality or increasing population size/vigor. Known techniques (such as cultivation, clearing of competing vegetation) will be considered and incorporated as appropriate into the conservation plans developed in Task 1.4. These techniques will then be refined and/or added to as warranted by the results of Tasks 2 and 3. Consideration will be given to the benefits and risks of re-establishing colonies on historical sites, establishing new colonies in areas identified as potential habitat, and expansion of existing colonies. The effects of implementing active management will be carefully monitored. (USFWS, 1991)
- 5. As needed. Preserve representative genotypes through plant cultivation. If a need is indicated, plants from marginal or highly threatened genotypes will be cultivated in qualified plant breeding facilities. Further, if shown to be technically feasible, the possibility of storing Helonias seed and/or plant tissue by cryopreservation will be considered. This would be followed by, as needed, breaking seed dormancy in the laboratory and/or using tissue culture as a method of replicating plants. (USFWS, 1991)

- 6. Provide public information and education. As Helonias is an attractive plant with considerable value to collectors, the means by which public information and education is achieved is a critical component of recovery. Outreach opportunities for educating concerned parties and the general public about the species will be identified, and appropriate informational materials will be developed. For instance, a color brochure that describes Helonias and the threats to its survival will be developed to increase public awareness and to aid in soliciting the cooperation of landowners and developers regarding site protection. While focusing on Helonias, this type of brochure can also be used to increase general awareness of endangered and threatened plants. Other opportunities that will be capitalized upon include displays for visitor centers at public recreational areas such as National Forests, National Parks, and various state lands; popular articles exposing the general public to the species and issues of managing endangered and threatened plant species; and visual media that could be presented in conjunction with school and civic programs. (USFWS, 1991)
- 7. Review recovery Progress and revise plan as necessary. Progress towards recovery will be reviewed on an annual basis, and this plan will be updated and revised as needed. (USFWS, 1991)
- Reevaluate Recovery Criteria in Light of New Information: - Conduct a population viability analysis (PVA) with cautious assumptions about collection, herbivory, beaver activity, woody vegetation encroachment, and climate change. - Use the results of the PVA to determine the importance and viability of C and D-ranked sites, and to determine if the recovery criteria need revision (particularly the number, type, and conditions for “protected” sites). (USFWS, 2014).
- Monitor and Track Recovery: - Develop criteria to determine which populations are representative of the species’ range, habitat, or genetic diversity, and identify those specific occurrences. - Develop a rapid assessment protocol to map and rank occurrences with minimal effort, expense, and disturbance in a consistent way across the range. Use the protocol to rank and map 20 percent of sites each year (e.g., a five-year cycle), using volunteers where possible. Make sure the information is entered in Natural Heritage Program databases. Track element occurrence ranks and plant numbers over time (USFWS, 2014).
- Watershed-Level Protection: Conduct a study to look for correlations between buffer width and changes in population size and vigor (USFWS, 2014).
- Watershed-Level Protection: Develop Best Management Practices to protect swamp pink habitat, and encourage their adoption by Federal and State regulatory agencies, local governments, and public and private landowners (USFWS, 2014).
- Watershed-Level Protection: Incorporate swamp pink in watershed planning, especially where multiple occurrences are clustered in small watersheds. Examples of watershed planning activities may include identifying priority areas for acquisition or conservation easements; mapping groundwater recharge areas; mapping up-gradient areas of steep slopes or highly erodible soils; and seeking protections through surface water quality standards, development design standards, or regulation of flood plains or stormwater management (USFWS, 2014).
- Site-Specific Protection: Work with public and private land trusts to acquire and manage important sites and buffers, prioritizing A and B-ranked sites and sites identified as representative of the species’ range, habitat, or genetic diversity (USFWS, 2014).

- Site-Specific Protection: Continue to seek landowner agreements to protect swamp pink on private lands where outright acquisition is a low priority or is not feasible (USFWS, 2014).
- Site-Specific Protection: Work with restoration groups to halt or reverse declines at impacted sites. Seek out new funding sources, such as those for non-point source pollution control or preservation of lands important to water supplies (USFWS, 2014).
- Site-Specific Protection: Continue to protect swamp pink sites through various regulatory processes as necessary and appropriate (USFWS, 2014).
- Propagation: Pursue long-term seed storage at CPC member institutions (USFWS, 2014).
- Propagation: Investigate the need, feasibility, methods, and opportunities for reintroduction of plants. Support research on propagation and genetics. Investigate how swamp pink colonizes new habitat under natural conditions to determine if natural dispersal is precluded in developed areas and could be augmented by reintroductions consistent with the Service's propagation policy (USFWS, 2014).
- Propagation: Develop partnerships with horticultural groups to learn more about the amount and origin of swamp pink in cultivation and trade for ornamental gardens. Work cooperatively with these partners to develop a statement of principles for responsible cultivation and trade of swamp pink (USFWS, 2014).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Identify Priority Sites • Investigate the genetic diversity of swamp pink occurrences range-wide (especially in states that are under-represented in existing genetic studies, including North Carolina, Virginia, Delaware, Maryland, and New Jersey). Smaller, less vigorous swamp pink occurrences can harbor significant genetic diversity (Godt et al. 1995) and must not be overlooked during sampling. Develop guidance or criteria to identify occurrences that are representative of the species' genetic diversity and designate those occurrences as priority sites for protection. (Section 2.2.3, Priority 2 action) • Develop guidance or criteria to identify the swamp pink occurrences that are representative of the species' range and habitat. Designate the occurrences that meet the criteria as priority sites for protection. (Section 2.2.3, Priority 2 action) • Develop a swamp pink-specific protocol for delimiting element occurrences and pursue uniform implementation across the species' range. Consider implementing 'parent and child' structure for element occurrences to delineate populations and their corresponding sub-populations/occurrences. (Section 2.3.1.2, Priority 3 action) Research to Inform Management • Conduct a study to look for correlations between buffer widths, level of watershed development, and changes in swamp pink population size and vigor over time. Use this information to develop guidance on adequate buffer size/acreage for swamp pink sites to be considered permanently protected. Investigate whether buffer enhancement activities can be implemented to achieve adequate buffer protection at swamp pink occurrences that already have development in the buffer zone. (Section 2.2.3, Priority 2 action) • Investigate the impacts of herbivory (at different frequencies and intensities) on the growth and survival of swamp pink in the short- and long-term, as well as potential synergistic interactions with other co-occurring threats (e.g., groundwater drawdown). Investigate alternate management strategies (e.g., habitat management to increase light availability) to mitigate the effect of herbivory in situations where deer cannot effectively be excluded. (Section 2.3.2.3, Priority 2 action) • Based on the results of research, create guidance that describes the minimum protections and management stipulations (to be tailored to the site-specific conditions) required for a swamp pink occurrence to be considered permanently protected. (Section 2.2.3, Priority 3 action) Safeguarding Actions • Develop a captive propagation plan for swamp pink that clarifies objectives of ongoing in-situ and ex-situ safeguarding efforts and their significance for

swamp pink recovery. (Section 2.2.3, Priority 2 action) • Pursue long-term storage (ex-situ safeguarding) of swamp pink seed and/or tissue at Center for Plant Conservation member institutions. Prioritize collection and preservation of occurrences that are known or suspected to be representative of the species' genetic diversity and are currently imperiled, or may become imperiled in the future. (Section 2.2.3, Priority 2 action) • Investigate the need, methods, and opportunities for the establishment of in-situ swamp pink safeguarding sites and/or reintroductions to sites that have become extirpated. (Section 2.2.3, Priority 3 action) Land Preservation and Management • Work with public and private land trusts to acquire and manage swamp pink priority sites and buffer areas. Continue to seek landowner agreements to protect swamp pink on private lands where outright acquisition is a low priority or is not feasible. (Section 2.2.3, Priority 3 action) • Work with restoration groups to halt or reverse declines at impacted sites. Seek out new funding sources, such as those for non-point source pollution control or preservation of lands important to water supplies. (Section 2.3.2.1, Priority 2 action) • Incorporate swamp pink in watershed planning, especially where multiple occurrences are clustered in small watersheds. Examples of watershed planning activities may include identifying priority areas for acquisition or conservation easements; mapping groundwater recharge areas; mapping up-gradient areas of steep slopes or highly erodible soils; and seeking protections through surface water quality standards, development design standards, or regulation of flood plains or stormwater management. (Section 2.3.2.1, Priority 3 action) Continue Survey Efforts • Continue surveying swamp pink occurrences, especially sites which haven't been surveyed in 20+ years and are nearing historic status. New Jersey and Delaware in particular have a significant number of sites that have not been visited for several decades but are still believed to be extant. Build relationships with private landowners and secure property access for swamp pink surveys. (Section 2.3.1.2, Priority 3 action) • Conduct de novo surveys for swamp pink in suitable habitat on public and private lands, especially in remote or otherwise undisturbed areas. Public lands have continued to yield new A- or B- ranked swamp pink occurrences in New Jersey, and discovery of new populations (or subpopulations) is also possible in the southern portion of the range (e.g., North Carolina). (Section 2.3.1.2, Priority 3 action) (USFWS, 2021)

References

USFWS. 2014. Swamp Pink (*Helonias bullata*), 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, New Jersey Field Office. 32 pp. December 30, 2014.
https://ecos.fws.gov/docs/five_year_review/doc4474.pdf

USFWS. 1991. Swamp Pink (*Helonias bullata*) Recovery Plan. U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 56 pp. https://ecos.fws.gov/docs/recovery_plan/910930c.pdf

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

USFWS 2014. Swamp Pink (*Helonias bullata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service New Jersey Field Office Pleasantville, New Jersey

U.S. Fish and Wildlife Service. 1991. Swamp Pink (*Helonias bullata*) Recovery Plan. Newton Corner, Massachusetts. 56 pp.

USFWS 2014. Swamp Pink (*Helonias bullata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service New Jersey Field Office Pleasantville, New Jersey. USFWS. 2021. Swamp Pink (*Helonias bullata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Northeast

Region New Jersey Field Office Galloway, New Jersey. 57 pp.

USFWS. 2008. Swamp Pink (*Helonias bullata*), 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, New Jersey Field Office. 53 pp. October 28, 2008.
https://ecos.fws.gov/docs/five_year_review/doc2006.pdf

USFWS. 2021. Swamp Pink (*Helonias bullata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Northeast Region New Jersey Field Office Galloway, New Jersey. 57 pp.

SPECIES ACCOUNT: *Iris lacustris* (Dwarf lake iris)

Species Taxonomic and Listing Information

Listing Status: Threatened; 09/28/1988; Great Lakes-Big Rivers Region (R3) (USFWS, 2016)

Physical Description

A low-growing perennial herb with fan-shaped clusters of flattened, sword-like leaves, about 1.6 dm high or less, arising from enlarged nodes on slender, creeping rhizomes. The showy blue (occasionally lilac or white) flowers with yellow splotches are borne singly on flowering stems no more than 4 cm long. Flowers emerge mostly from mid- to late-May (NatureServe, 2015).

Taxonomy

Dwarf lake iris is classified within the subgenus *Limniris*, one of the six subgenera of *Iris* and which includes all of the native iris species of North America, a group frequently referred to as the beardless irises (Henderson 2002). Although *I. lacustris* has sometimes been treated as a subspecies of *I. cristata* (Dykes 1913; Mason and Iltis 1965), most authors recognize dwarf lake iris as a distinct species, based on consistent and marked differences in morphology, geographical range, and habitat (Small 1924; Foster 1937) (USFWS, 2013).

Historical Range

Dwarf lake iris is endemic to the modern and ancient shorelines of northern Lakes Huron and Michigan. Historical records indicate that it once occurred as far south as Milwaukee, Wisconsin (Anderson, in litt. 2005) and possibly along the Detroit River (near Sandwich) in Ontario (COSEWIC 2004) (USFWS, 2011).

Current Range

Almost exclusively found on the northern shores of Lakes Michigan, Huron and Superior. Approximate range extent is 4100 sq. miles (NatureServe, 2015). The global population of dwarf lake iris is collectively restricted to Michigan, Wisconsin, and Ontario (USFWS, 2011).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual: cross-pollination, self-pollination, asexual: vegetative (USFWS, 2011 and USFWS, 2013). Pollinated by halictid bees and other bee species (USFWS, 2022)

Lifespan

Adult: 2+ years (inferred from USFWS, 2013)

Dependency on Other Individuals or Species

Adult: The only identified pollination vector was halictid bees (*Augochlorella striata*, Larson 1998, p. 523). Additional pollination vectors have since been identified, including bee species

from 4 families (*Adrena carlini*, *Bombus vagans*, *Bombus impatiens*, *Bombus affinis*, *Augochlorella persimilis*, *Augochlorella striata*, and *Hoplitis* spp.), the bee hawk-moth (*Hemaris affinis*), and a species of rove beetle (COSEWIC 2010, p. 17; Brotske 2018, p. 14). Visitation of dwarf lake iris by bees was positively related to the number of open flowers in the area (Brotske 2018, p. 18).

Breeding Season

Adult: April - June (USFWS, 2013). Seedlings appeared at the beginning of the growing season and continued to appear throughout the summer (USFWS, 2022).

Key Resources Needed for Breeding

Adult: Partial shade (NatureServe, 2015); possibly halictid bees (USFWS, 2011); possibly bee flies, several months of cold temperatures, soil seed bank (USFWS, 2013). Number of seedlings was positively related to light availability and number of ramets (the individual members of a clone) (Brotske 2018, p. 20) (USFWS, 2022).

Other Reproductive Information

Adult: As discussed in the 2011 5-year review, previous research has found limited heterozygosity and gene flow in dwarf lake iris populations (Orick 1992, entire; Simonich and Morgan 1994, entire). More recent and advanced genetic analysis has found increased genetic diversity within the species (Cohen et al. 2021, entire). The greatest amount of genetic diversity was found in inland Michigan populations (Cohen et al. 2021, entire). This aligns with previous research that suggested inland populations represent relics containing more diverse genomes (Orick 1992, entire)

Reproduction Narrative

Adult: While it has been found in full sun and nearly complete shade, optimal sexual reproduction appears to occur in partially shaded or sheltered forest edges (NatureServe, 2015). Larson (1998) reported halictid bees (*Augochlorella striata*) visiting dwarf lake iris flowers at Dorcas Bay, Bruce Peninsula, Ontario in late May 1996. Observations of floral visitation and grooming behaviors suggest halictid bees are potential pollinators. Dwarf lake iris seed capsules, on average, contain 20 - 22 small seeds (Planisek 1983). Dwarf lake iris allocates a far lower percentage of resources to sexual than to vegetative reproduction (USFWS, 2011). Dwarf lake iris is a spring flowering perennial. Flowering usually occurs from late April to early June, typically peaking from about mid-May to early June. Although dwarf lake iris is self-compatible, fruit set requires a pollen vector (Planisek 1983; Van Kley 1989). Van Kley (1989) reported bee flies (*Bombyliidae*) visiting flowers and probing in such a way that contact with stigma/stamens was likely. Field observations and laboratory studies indicate that seeds are dormant at the time of dispersal and require several months of cold temperatures for germination but can remain viable for at least 15 years within a soil bank (Morgan and Wolf 2008) (USFWS, 2013). Recent research on pollination, seed dispersal, and germination suggest sexual reproduction may be contributing more to dwarf lake iris populations than previously believed (Brotske 2018, entire). Research at the time of the last 5-year review suggested dwarf lake iris had low flower production, fruit set, and seed production. This indicated limited pollination, though seed viability may also be a limiting factor (Doyle 2015, p. 3). The only identified pollination vector was halictid bees (*Augochlorella striata*, Larson 1998, p. 523). Additional pollination vectors have since been identified, including bee species from 4 families (*Adrena carlini*, *Bombus vagans*, *Bombus impatiens*, *Bombus affinis*, *Augochlorella persimilis*, *Augochlorella striata*, and *Hoplitis*

spp.), the bee hawk-moth (*Hemaris affinis*), and a species of rove beetle (COSEWIC 2010, p. 17; Brotske 2018, p. 14). Visitation of dwarf lake iris by bees was positively related to the number of open flowers in the area (Brotske 2018, p. 18). We note declines in bee abundance and richness have been documented in the Great Lakes basin (e.g., Graham et al. 2021, entire) and plan to evaluate how changes in pollinator abundance and richness may be potentially affecting dwarf lake iris population resilience in an upcoming Species Status Assessment (SSA). Dwarf lake iris seed capsules contain 20-22 seeds, each with an attached elaiosome (fleshy structures attached to a seed) (Planisek 1983, pp. 93-99). Studies in Michigan and Wisconsin have shown ants (*Formica* spp.) will remove these seeds and likely play a role in seed dispersal (Planisek 1983, p. 99; Brotske 2018, p. 18). Further studies on dispersal by ants are needed to understand how far and where ants distribute seeds (Brotske 2018, p. 23). Seed germination has been reported rarely for dwarf lake iris populations. Recent research suggests seed germination may be more common than initially believed (Brotske 2018, p. 14). Up to 36 individual seedlings were found in 400 cm² plots at 2 sites in Wisconsin (Brotske 2018, p. 20). Seedlings appeared at the beginning of the growing season and continued to appear throughout the summer. Seedlings can be identified by the presence of a bright green loop at the top of the plant. This loop begins to shrivel within 2 weeks of emergence, which may explain why previous studies have reported low germination (Brotske 2018, pp. 25-27). Soil disturbance did not affect the number of seedlings that germinated. Number of seedlings was positively related to light availability and number of ramets (the individual members of a clone) (Brotske 2018, p. 20). Research over two years in Wisconsin showed an inconsistent relationship between seed viability and canopy cover. Seed viability is likely tied to seasonal conditions, such as rainfall, and shaded conditions may prove more favorable during drought conditions (Doyle 2015, p. 3). (USFWS, 2022).

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Coniferous forest (USFWS, 2011)

Dependencies on Specific Environmental Elements

Adult: Natural disturbance processes (USFWS, 2011)

Geographic or Habitat Restraints or Barriers

Adult: Succession (NatureServe, 2015; see population narrative); thick leaf litter (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Colonial (USFWS, 2011)

Environmental Specificity

Adult: Narrow (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from USFWS, 2011)

Habitat Narrative

Adult: Thrives best in close proximity to the northern Great Lakes shores, where it is most often found in young, well-drained soils ranging from sands to gravels to sandy clay loam and organic-enriched sands. Distributional and field data demonstrate that it achieves its best growth in calcareous environments. It is most often associated with coniferous forest dominated by northern white-cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*). Old beach ridges associated with post-glacial shorelines, many occurring significant distances inland from current lake shores, provide similar habitat that often supports the species, but in many of these inland sites the species persists mostly as sterile colonies, slowly senescing under the shade of more mature overstory vegetation. The environmental specificity is narrow; edaphic and canopy factors are important (NatureServe, 2015). Geographically distinct occurrences, consisting of more or less contiguous colonies, are used to estimate the overall abundance (Michael Penskar, Michigan Natural Features Inventory, pers. comm. 1998). It is most often associated with coniferous forest dominated by northern white-cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*) (Van Kley 1989). Thick leaf litter restricts seedling establishment either by preventing the developing roots from reaching mineral soil or by preventing the developing shoot from reaching light (Makholm 1986). Cyclical fluctuations of Great Lakes levels and other factors, such as wind, waves and winter ice formations, are significant natural disturbance features (Van Kley 1989). These disturbance processes create a ragged forest edge as well as forest openings and gaps in the canopy that provide microsites for subsequent colonization by dwarf lake iris (Van Kley 1989). This species is a persistent and rather ecologically resilient plant that can withstand some level of disturbance and can often recolonize small disturbed areas if it flourishes nearby (Penskar et al. 2001) (USFWS, 2011). Van Kley (1989) found that soil pH varied from 5.4 to 7.5, although most measurements were above 6.5. (USFWS, 2013).

Dispersal/Migration

Dispersal

Adult: Low (USFWS, 2013). Possibly dispersed by ants (USFWS, 2022)

Dispersal/Migration Narrative

Adult: Although Planisek (1983) demonstrated that ants are attracted to and will move dwarf lake iris seeds, the extent of their role, if any, in the dispersal of this species is not known. It has an apparent limited dispersal ability (even nearby microsites that appear favorable often support no plants) (USFWS, 2013).

Population Information and Trends

Population Trends:

Increasing (USFWS, 2022)

Species Trends:

Stable (USFWS, 2011); Increasing (USFWS, 2021)

Number of Populations:

165 (USFWS, 2022)

Population Size:

10,000 to >1,000,000 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Can colonize suitable habitats (roadside ditches, etc.), not tolerant to long-term flooding. The species has low genetic diversity and low rate of sexual reproduction. This species has experienced a long term decline of 50 - 80%. The number of genets is unknown, but likely over 10,000. This number is likely in the hundreds of millions (NatureServe, 2015). Overall, the total population of dwarf lake iris appears relatively stable (USFWS, 2011). There are 167 extant occurrences (USFWS, 2013). Though dwarf lake iris remains a rare endemic species with a limited distribution, the species has increased since its listing, and analyses suggest the species is likely to persist for several decades at a minimum. Since listing, the number of known dwarf lake iris occurrences has increased from approximately 118 to 165 extant occurrences (USFWS, 2022). At the time of the previous 5-year review in 2011, there was a total of 143 known extant occurrences of dwarf lake iris: 84 in Michigan, 41 in Wisconsin, and 18 in Ontario, Canada. There is now a total of 165 known extant occurrences (Figure 1). In Michigan, there are 89 extant occurrences of dwarf lake iris (Hackett et al. 2021, p. 15). These occurrences mainly exist along the Great Lakes shorelines of the northern Lower Peninsula and the southern Upper Peninsula, though there are some anomalous inland occurrences. In Wisconsin, there are 36 extant occurrences of dwarf lake iris (Owen Boyle, Wisconsin Department of Natural Resources, pers. comm. 2021). (USFWS 2022)

Threats and Stressors

Stressor: Development (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: Loss of shoreline habitat is increasing along Lakes Michigan and Huron in part due to residential, especially second home, development. Habitat is physically destroyed by home construction, driveways, access roads, associated landscaping, and long-term maintenance, such as mowing (Penskar, pers. comm. 1998). Home development can also fragment habitat. The main threat to dwarf lake iris on private property is cottage development; however, cottage owners sometimes maintain natural landscaping around cottages, allowing dwarf lake iris to survive (COSEWIC 2004). Major recreational activities along the northern Great Lakes shores include sightseeing, fishing, camping, hiking, boating, skiing, and hunting. With the influx of vacationers from the south, the market for constructed attractions, such as golf courses, amusements and shopping, has also increased (Penskar, pers. comm. 1998). In Michigan, marina development along the Great Lakes is being fueled by high demand and the State of Michigan's Harbor Development Fund (USFWS, 2011).

Stressor: Road maintenance and construction (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: Approximately one half of the occurrence records for dwarf lake iris mention proximity to roads or trails. Great threats are posed by road maintenance activities, such as

mowing, grading, brush and tree removal, and herbicide spraying. Road construction projects under the jurisdiction of counties or municipalities can have much greater impacts on dwarf lake iris. There is currently no program for protecting dwarf lake iris growing along local roads either in Wisconsin or Michigan. Roads in proximity to dwarf lake iris populations also create risks to the species by providing access routes for construction of residences and driveways (Penskar, pers. comm. 1998). This development further destroys and fragments the species' habitat (USFWS, 2011). Survey efforts in the last 10 - 55 years have failed to find eight populations of dwarf lake iris that historically occurred in Michigan (Hackett et al. 2021, p. 27). All but one of these populations was near a roadside or a developing residential area, although it is unknown if anthropogenic stressors contributed to the decline in these populations. There are several seemingly stable populations of dwarf lake iris that continue to persist on residential property and along roadsides (Hackett et al. 2021, p. 27) (USFWS, 2022).

Stressor: Succession (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: The main natural threat to dwarf lake iris is forest succession. Specifically, the invasion of deciduous species can result in reduced light levels and increased leaf litter, which inhibits successful reproduction, as discussed in section 2.3.1.6. The long-term survival of dwarf lake iris requires some form of disturbance that alters or suppresses succession, which aids in maintaining occupied habitat as well as creating new areas of suitable habitat (Makholm 1986). Orange hawkweed (*Hieracium aurantiacum* L.), an exotic species, has similar ecological requirements and may compete with dwarf lake iris for its open habitat. This species has been observed invading existing dwarf lake iris colonies, and it occupies areas that could have potentially supported dwarf lake iris (Gibson and Makholm 1988) (USFWS, 2011).

Stressor: Climate change (USFWS, 2011)

Exposure:

Response:

Consequence:

Narrative: Regional warming may result in shifts in forest distribution (Kling et al. 2003). As the extent of canopy cover and leaf litter influence dwarf lake iris populations, changes to forest species composition and/or distribution of forest cover across the landscape could affect the long-term survival of the species. Drier conditions could also have a significant adverse effect on the suitability of microhabitats, particularly in open sites with constant solar exposure (Morgan 1989). How Great Lakes water levels may change and what effect this may have on habitat availability and suitability for dwarf lake iris is unclear (USFWS, 2011).

Stressor: Invasive Species (USFWS, 2022)

Exposure:

Response:

Consequence:

Narrative: Many invasive species have been observed near dwarf lake iris populations, including spotted knapweed (*Centaurea stoebe*), invasive hawkweed (*Hieracium* spp.), reed canary grass (*Phalaris arundinacea*), honeysuckle (*Lonicera morrowii*, *Lonicera x bella*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), wall lettuce (*Mycelis muralis*), common barberry (*Berberis vulgaris*), Japanese barberry (*Berberis thunbergii*), and common buckthorn (*Rhamus*

cathartica) (Brotske 2018, p. 28; Hackett et al. 2021, p. 30). Shading by invasive shrubs and taller grasses is likely the greatest threat posed by invasive species (Hackett et al. 2021, p. 30). Early detection and removal are the most cost-effective ways to address this threat. (USFWS, 2022)

Recovery

Reclassification Criteria:

Recovery Priority Number: 8C

Delisting Criteria:

1. The species has a 95% probability of persistence within the next 20 years, based on data obtained from accepted standardized monitoring methods and on population viability analysis. In order to meet this criterion, the following must be verified: a. There is a sufficient number and geographical distribution of element occurrences required to ensure long-term persistence; b. Each element occurrence needed to ensure a 95% probability of persistence within the next 20 years must meet a minimum viable population size and exhibit an increasing or stable population trend over a 10-year period (USFWS, 2013).
2. Management plans have been developed and are being implemented to protect and manage the habitat associated with the element occurrences identified in Criterion 1.b. (USFWS, 2013).
3. A plan to provide public outreach and education for dwarf lake iris has been developed and is being implemented (USFWS, 2013).

Recovery Actions:

- Protect occurrences (USFWS, 2013).
- Manage and restore habitat (USFWS, 2013).
- Inventory and monitor known sites (USFWS, 2013).
- Conduct population viability analysis (USFWS, 2013).
- Develop an education program about dwarf lake iris, other federally listed shoreline species, natural communities, and their protection and management (USFWS, 2013).
- Improve understanding of baseline dwarf lake iris ecology (USFWS, 2013).
- Review and track recovery progress (USFWS, 2013).
- Complete the recovery plan for *I. lacustris*. This plan will identify objective recovery criteria and develop a recovery strategy (USFWS, 2011).
- Develop a monitoring schedule to ensure the continued health and stability of the known *I. lacustris* occurrences. An established monitoring system will aid in determining population trends within and among colonies (USFWS, 2011).
- Establish a public outreach program to increase public awareness of *I. lacustris* and to notify private landowners of the species' presence. This informative program will promote overall recovery of the species and decrease unintentional destruction on both public and private land (USFWS, 2011).
- Develop state and Federal management plans that address protection of *I. lacustris* in dedicated and multiple-use areas (USFWS, 2011).
- Develop Best Management Practices for use by State and County Highway Departments for roadside populations of *I. lacustris* (USFWS, 2011).

- Encourage research to better understand how vegetation management of existing sites can be designed to benefit *I. lacustris* (USFWS, 2011).

Conservation Measures and Best Management Practices:

- Michigan Natural Features Inventory received funding from the Great Lakes Restoration Initiative to evaluate dwarf lake iris populations in Michigan. A total of 58 dwarf lake iris element occurrences were visited from 2019 to 2021 (Hackett et al. 2021, entire). Efforts ranged from qualitative surveys (quick, presence/absence survey that can happen at any time in the growing season), to count surveys (must be conducted during flowering, more time consuming but provide more rigorous data on populations), to demographic surveys (most labor intensive but provide the most data), depending on the site. The Michigan Natural Heritage Database was updated to reflect new information on population status and threats, and this information was used to develop the PVAs (USFWS, 2022).
- Recommendations for future actions: • Develop and implement Site Management Plans (Recovery Plan Action 2.1) • Develop and implement an outreach program for schools, landowners, local communities, developers, utilities, and county road associations (Recovery Plan Actions 5.1, 5.2, and 5.3) • Conduct a SSA to inform the next 5-year review (Recovery Plan Action 7.1) • Plan and implement regular surveys and monitoring of occurrences to understand population status and inform a species level PVA (Recovery Plan Actions 3 and 4) (USFWS, 2022).
- Since the last 5-year review, three formal section 7 consultations have been conducted for projects affecting dwarf lake iris: development of a motor coach recreational park including construction of a boardwalk in Cheboygan County (Service 2014, entire), an overhead transmission line in Presque Isle and Cheboygan Counties, Michigan (Service 2019, entire), and a pipeline in Mackinac County, Michigan (Service 2020, entire). These projects used several conservation measures to minimize impacts to dwarf lake iris, including using existing roads and timber mats to minimize impacts to the population, cleaning all equipment to prevent invasive species, treating existing invasive species to prevent further establishment, and informing all workers about the unique characteristics and sensitivity of dwarf lake iris. For all three projects, at least a portion of the ramets that could not be avoided during construction were transplanted off site and monitored for at least 2 years (Service 2014, p. 4; Service 2019, pp. 13-14; Service 2020, pp. 7-10). Various methods have been used to transplant dwarf lake iris, including manual excavation and transplantation for small areas and the use of a mechanical sod cutter to relocate large areas of dwarf lake iris (Vande Water Natural Resource Services 2011, pp. 2-5). Monitoring of one relocation effort showed 83 – 91% of dwarf lake iris ramets that were transplanted continued to grow 2 years later (Barr 2013, p. 8). A similar transplantation method was used to move 550 ramets from a private site undergoing construction in Wisconsin to a new location with no known populations of dwarf lake iris but appropriate habitat conditions (Collins 2020, entire) (USFWS, 2022).

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed July 2016

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

USFWS 2011. Dwarf Lake Iris (*Iris lacustris*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service East Lansing Field Office East Lansing, Michigan

U.S. Fish and Wildlife Service. 2013. Dwarf lake iris (*Iris lacustris*) Recovery Plan. Bloomington, Minnesota. vii + 75 pp.

U.S. Fish and Wildlife Service. 2013. Dwarf lake iris (*Iris lacustris*) Recovery Plan. Bloomington, Minnesota. vii + 75 pp. USFWS. 2022. STATUS REVIEW Dwarf lake iris (*Iris lacustris*). 10 pp.

U.S. Fish and Wildlife Service. 2013. Dwarf lake iris (*Iris lacustris*) Recovery Plan. Bloomington, Minnesota. vii + 75 pp. USFWS. 2022. STATUS REVIEW. Dwarf lake iris (*Iris lacustris*). 10 pp.

USFWS. 2011. Dwarf Lake Iris (*Iris lacustris*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service East Lansing Field Office East Lansing, Michigan.

USFWS. 2022. STATUS REVIEW. Dwarf lake iris (*Iris lacustris*). 10 pp.

USFWS 2011. Dwarf Lake Iris (*Iris lacustris*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service East Lansing Field Office, East Lansing, Michigan.

SPECIES ACCOUNT: *Ischaemum byrone* (Hilo ischaemum)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/04/1994; Pacific Region (Region 1) (USFWS, 2016a)

Physical Description

Ischaemum byrone (Trin.) Hitchc. is a perennial grass with creeping underground stems and erect stems 16-31 in (40-80 cm) tall (O'Connor 1990). The lower portion of the leaf that surrounds the stem (sheath) sometimes exhibits long hair near the base, while the upper portion is often inflated and encloses the yellow-brown flower clusters (inflorescences). The flat, hairless leaf blades are 2.8-7.9 in (7-20 cm) long and 1.2-2 in (3-5 cm) wide, decreasing in size toward the top of the plant. Branches of the flower clusters originate at one point in twos and threes (digitate). Two-flowered spikelets (basic units of an inflorescence) are of two types: 1) one unit is sessile with a twisted bristle (awn), 0.9-1.0 in (2.4-2.6 cm) long; and 2) one unit is stalked with a red-brown awn, 0.6-0.8 in (1.5-2cm), which is twisted toward the base. The fruit is a golden oval grain (caryopsis) about 0.1 in (3mm) long. (USFWS, 1996)

Taxonomy

Trinius (1830) named the taxon *Spodiopogon byronis* Trin., the specific epithet honored the collection's location in Byron's bay. Steudel (1855) moved the taxon to the genus *Andropogon* and named it *A. byronis* (Trin.) Steud. In 1889, Hackel redescribed the taxon and placed it in the genus *Ischaemum*, naming it *Ischaemum lutescens* Hack. for the yellow-brown color of the inflorescence. The name was considered superfluous and, in 1922, Hitchcock recognized the original specific epithet and published the currently accepted nomenclature, *Ischaemum byrone* (O'Connor 1990, 59 FR 10305). (USFWS, 1996)

Historical Range

Historically known from Kauai, Oahu, Molokai, east Maui, and Hawaii island (USFWS, 2016b).

Current Range

Currently known from Kauai, Molokai, east Maui, and Hawaii island (USFWS, 2016b). Island Distribution: Found on Kauai, Oahu, Molokai, Maui and Hawaii.(USFWS, 2021c)

Critical Habitat Designated

Yes; 2/27/2003.

Legal Description

On March 30, 2016, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Ischaemum byrone* (Hilo ischaemum) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes 13 detailed critical habitat units (CHUs), in Hawaii (81 FR 17790-18110).

On July 2, 2003, the U.S. Fish and Wildlife Service (Service), designated critical habitat pursuant to the Endangered Species Act of 1973, as amended (Act), for *Ischaemum byrone* on the island of Hawaii (68 FR 39623 - 39722).

On February 27, 2003, the U.S. Fish and Wildlife Service (Service), designate critical habitat pursuant to the Endangered Species Act of 1973, as amended (Act), for *Ischaemum byrone* on the island of Kauai, Hawaii (68 FR 9116 - 9479).

Critical Habitat Designation

The critical habitat designation for *Ischaemum byrne* includes 13 CHUs in Maui County, Hawaii with detailed unit information (81 FR 17790-18110).

Molokai—Coastal—Unit 1 consists of 70 ac (28 ha) of privately owned land, and 54 ac (22 ha) of federally owned land (U.S. Coast Guard) at Laau Point, from Kahaiawa to Keawakalani, along the western coast of Molokai. This unit is occupied by the plant *Marsilea villosa*, and includes the mixed hermland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of this species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai—Coastal—Unit 1 is not known to be occupied by *Bidens wiebkei*, *Brighamia rockii*, *Canavalia molokaiensis*, *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *Ischaemum byrne*, *Peucedanum sandwicense*, *Pittosporum halophilum*, *Schenkia sebaeoides*, *Sesbania tomentosa*, or *Tetramolopium rockii*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Coastal—Unit 2 consists of 263 ac (106 ha) of State land, and 710 ac (287 ha) of privately owned land, from Ilio Point to Kaa Gulch, along the northwestern coast of Molokai. This unit is occupied by the plant *Marsilea villosa* and includes the mixed hermland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of this species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai—Coastal—Unit 2 is not known to be occupied by *Bidens wiebkei*, *Brighamia rockii*, *Canavalia molokaiensis*, *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *Ischaemum byrne*, *Peucedanum sandwicense*, *Pittosporum halophilum*, *Schenkia sebaeoides*, *Sesbania tomentosa*, or *Tetramolopium rockii*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Maui—Coastal—Unit 3 consists of 10 ac (4 ha) of privately owned land at Pauwalu Point on the northern coast of east Maui. This unit is occupied by the plant *Ischaemum byrne* and includes the mixed hermland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of this species by providing the PCEs necessary for the expansion of the existing wild populations. Although Maui—Coastal—Unit 3 is not known to be occupied by *Brighamia rockii*, *Cyperus pennatifolius*, *Peucedanum sandwicense*, or *Vigna o-wahuensis*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for

expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Coastal—Unit 3 consists of 794 ac (321 ha) of State land, and 3 ac (1 ha) of federally owned land (Kalaupapa National Historical Park), from Kahi Point to Wainene, along the north-central coast of Molokai. This unit is occupied by the plants *Pittosporum halophilum*, *Schenkia sebaeoides*, and *Tetramolopium rockii*, and includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of these species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai—Coastal—Unit 3 is not known to be occupied by *Bidens wiebkei*, *Brighamia rockii*, *Canavalia molokaiensis*, *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *Ischaemum byrone*, *Marsilea villosa*, *Peucedanum sandwicense*, or *Sesbania tomentosa*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Maui—Coastal—Unit 4 consists of 40 ac (16 ha) of State land, and 35 ac (14 ha) of privately owned land, from Papiha Point to Honolulu Nui Bay on the northeastern coast of east Maui. This unit is occupied by the plant *Cyperus pennatiformis* and includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of this species by providing the PCEs necessary for the expansion of the existing wild populations. Although Maui—Coastal—Unit 4 is not known to be occupied by *Brighamia rockii*, *Ischaemum byrone*, *Peucedanum sandwicense*, or *Vigna owahuensis*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Coastal—Unit 4 consists of 10 ac (4 ha) on Mokapu Island on the northern coast of Molokai. This area is State-owned, and is classified as a State Seabird Sanctuary. This unit is occupied by the plants *Peucedanum sandwicense* and *Pittosporum halophilum*, and includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of these species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai—Coastal—Unit 4 is not known to be occupied by *Bidens wiebkei*, *Brighamia rockii*, *Canavalia molokaiensis*, *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *Ischaemum byrone*, *Marsilea villosa*, *Schenkia sebaeoides*, *Sesbania tomentosa*, or *Tetramolopium rockii*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Maui—Coastal—Unit 5 consists of 26 ac (11 ha) of State land from Keakulikuli Point to Pailoa Bay on the northeastern coast of east Maui. This unit is occupied by the plant *Ischaemum byrnone* and includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of this species by providing the PCEs necessary for the expansion of the existing wild populations. Although Maui—Coastal—Unit 5 is not known to be occupied by *Brighamia rockii*, *Cyperus pennatifolius*, *Peucedanum sandwicense*, or *Vigna o-wahuensis*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Coastal—Unit 5 consists of 1 ac (0.5 ha) on Huelo islet on the northern coast of Molokai. This area is State-owned, and is classified as a State Seabird Sanctuary. This unit is occupied by the plants *Brighamia rockii*, *Peucedanum sandwicense*, and *Pittosporum halophilum*, and includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of these species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai—Coastal—Unit 5 is not known to be occupied by *Bidens wiebkei*, *Canavalia molokaiensis*, *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *Ischaemum byrnone*, *Marsilea villosa*, *Schenkia sebaeoides*, *Sesbania tomentosa*, or *Tetramolopium rockii*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Maui—Coastal—Unit 6 consists of 356 ac (144 ha) of State land at Kamanamana on the southern coast of East Maui. This unit is occupied by the plant *Vigna owahuensis* and includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of this species by providing the PCEs necessary for the expansion of the existing wild populations. Although Maui—Coastal—Unit 6 is not known to be occupied by *Brighamia rockii*, *Cyperus pennatifolius*, *Ischaemum byrnone*, or *Peucedanum sandwicense*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within the historical ranges of the species. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Coastal—Unit 6 consists of 190 ac (77 ha) of State land, and 1,685 ac (682 ha) of privately owned land, from Kaholaiki Bay to Halawa Bay, on the northeastern coast of Molokai. This unit is occupied by the plants *Bidens wiebkei*, *Canavalia molokaiensis*, *Hibiscus arnottianus* ssp. *immaculatus*, and *Ischaemum byrnone*, and includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as

physical or biological features in the coastal ecosystem (see Table 5). This unit also contains unoccupied habitat that is essential to the conservation of these species by providing the PCEs necessary for the expansion of the existing wild populations. Although Molokai—Coastal—Unit 6 is not known to be occupied by *Brighamia rockii*, *Hibiscus brackenridgei*, *Marsilea villosa*, *Peucedanum sandwicense*, *Pittosporum halophilum*, *Schenkia sebaeoides*, *Sesbania tomentosa*, or *Tetramolopium rockii*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Maui—Coastal—Unit 7 consists of 30 ac (12 ha) of State land, and 15 ac (6 ha) of privately owned land, from Kailio Point to Waiuha Bay, on the southern coast of east Maui. This unit includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). Although Maui—Coastal—Unit 7 is not currently occupied by *Brighamia rockii*, *Cyperus pennatifolius*, *Ischaemum byrsoniifolium*, *Peucedanum sandwicense*, or *Vigna owahuensis*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within the historical ranges of the species. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Molokai—Coastal—Unit 7 consists of 49 ac (20 ha) of privately owned land from Alanuihipaka Ridge to Kalanikaula, on the northeastern coast of Molokai. This unit includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). Although Molokai—Coastal—Unit 7 is not known to be occupied by *Bidens wiebkei*, *Brighamia rockii*, *Canavalia molokaiensis*, *Hibiscus arnottianus* ssp. *immaculatus*, *H. brackenridgei*, *Ischaemum byrsoniifolium*, *Marsilea villosa*, *Peucedanum sandwicense*, *Pittosporum halophilum*, *Schenkia sebaeoides*, *Sesbania tomentosa*, or *Tetramolopium rockii*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within their historical range. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

Maui—Coastal—Unit 8 consists of 493 ac (199 ha) of State land from Kiakaua Point to Manawainui on the southern coast of east Maui. This unit includes the mixed herbland and shrubland, the moisture regime, and canopy, subcanopy, and understory native plant species identified as physical or biological features in the coastal ecosystem (see Table 5). Although Maui—Coastal—Unit 8 is not currently occupied by *Brighamia rockii*, *Cyperus pennatifolius*, *Ischaemum byrsoniifolium*, *Peucedanum sandwicense*, or *Vigna owahuensis*, we have determined this area to be essential for the conservation and recovery of these coastal species because it provides the PCEs necessary for the reestablishment of wild populations within the historical ranges of the species. Due to their small numbers of individuals or low population sizes, suitable habitat and space for expansion or reintroduction are essential to achieving population levels necessary for recovery.

The critical habitat designation for *Ischaemum byrone* includes two units totaling 903 acres in Hawaii county, Hawaii. The units are Hawaii 21—*Ischaemum byrone*—a and Hawaii 22—*Ischaemum byrone*—b. Each unit is geographically separated from other critical habitat for this multi-island species in order to reduce the likelihood of all recovery populations on the island being destroyed by one naturally occurring catastrophic event. Within the two units designated for *I. byrone* on the island of Hawaii in this rule, habitat is provided for a total of three populations, each with 300 mature, reproducing individuals.

Hawaii 21—*Ischaemum byrone*—a [206 ha (510 ac)]: This unit lies along the coast from just east of Keauhou Point, running west. The unit is bordered by the Kapapala watershed in the east and the Kilauea watershed in the west and lies completely within the HVNP. This unit provides habitat for 2 populations of 300 individuals of *I. byrone* and is currently unoccupied. This unit is essential to the conservation of the species because it supports habitat that is necessary for the establishment of additional populations in order to reach recovery goals. This unit provides the southernmost critical habitat within the species' historical range.

Hawaii 22—*Ischaemum byrone*—b [159 ha (393 ac)]: This unit lies along the coast from just east of Ka Lae Apuki to just east of Puu Manawalea and is completely within the HVNP. The unit provides habitat for 1 population of 300 individuals of *I. byrone* and is currently occupied by 200 individuals. This unit is essential to the conservation of *I. byrone* because it supports an extant colony of this species and includes habitat that is important for the expansion of the present population, which is currently considered nonviable.

The critical habitat designation for *Ischaemum byrone* includes four units totaling 140 acres in Kauai County, Hawaii. The units are Kauai 1—*Ischaemum byrone*—a, Kauai 2—*Ischaemum byrone*—b, Kauai 3—*Ischaemum byrone*—c, and Kauai 11—*Ischaemum byrone*—d.

Kauai 1—*Ischaemum byrone*—a: This unit is critical habitat for *Ischaemum byrone* and is 0.4 ha (1 ac) on private land at Hanalei Point. This unit, in combination with unit 1—*Ischaemum byrone*—b, provides habitat for one population of 300 mature, reproducing individuals of the shortlived perennial *Ischaemum byrone* and is currently occupied with one plant. This unit is essential to the conservation of the taxon because it supports an extant colony of this species and includes habitat that is important for the expansion of the present population, which is currently considered nonviable. It provides habitat for the westernmost range of the species. The habitat features contained in this unit that are essential for this species include, but are not limited to, coastal shrubland near the ocean among rocks and seepy cliffs. This unit, together with the other unit, provides for one population within this multi-island species' historical range on Kauai that is some distance away from the other critical habitat for this species, in order to avoid all recovery populations from being destroyed by one naturally occurring catastrophic event.

Kauai 2—*Ischaemum byrone*—b: This unit is critical habitat for *Ischaemum byrone* and is 6 ha (15 ac) on private land, containing Kaweonui Point. This unit, in combination with unit 1—*Ischaemum byrone*—a, provides habitat for one population of 300 mature, reproducing individuals of the short-lived perennial *Ischaemum byrone* and is currently unoccupied. This unit is essential to the conservation of the taxon because it supports habitat that is important to the establishment of additional populations on Kauai in order to reach recovery goals. It provides habitat for the westernmost range of the species. The habitat features contained in this unit that

are essential for this species include, but are not limited to, coastal shrubland near the ocean among rocks and seepy cliffs. This unit, together with the other unit, provides for one population within this multi-island species' historical range on Kauai that is some distance away from the other critical habitat for this species, in order to avoid all recovery populations from being destroyed by one naturally occurring catastrophic event.

Kauai 3—*Ischaemum byrone*—c: This unit is critical habitat for *Ischaemum byrone* and is 6 ha (16 ac) on private land along the cliffs of Kauapea Beach. This unit provides habitat for one population of 300 mature, reproducing individuals of the short-lived perennial *Ischaemum byrone* and is currently occupied with one plant. This unit is essential to the conservation of the taxon because it supports an extant colony of this species and includes habitat that is important for the expansion of the present population, which is currently considered non-viable. It provides habitat for the westernmost range of the species. The habitat features contained in this unit that are essential for this species include, but are not limited to, coastal shrubland near the ocean among rocks and seepy cliffs. This unit provides for one population within this multi-island species' historical range on Kauai that is some distance away from the other critical habitat for this species, in order to avoid all recovery populations from being destroyed by one naturally occurring catastrophic event.

Kauai 11—*Ischaemum byrone*—d: This unit is critical habitat for *Ischaemum byrone* and is 45 ha (111 ac) on State land (Hono o Na Pali NAR and Na Pali Coast State Park). This unit contains portions of Hanakapiai Beach, Hoolulu and Hanakapiai Streams. This unit provides habitat for one population of 300 mature, reproducing individuals of the short-lived perennial *Ischaemum byrone* and is currently unoccupied. This unit is important to the conservation of the taxon because it supports habitat that is important to the establishment of additional populations on Kauai in order to reach recovery goals. It provides habitat for the westernmost range of the species. The habitat features contained in this unit that are essential for this species include, but are not limited to, coastal shrubland near the ocean among rocks and seepy cliffs. This unit provides for one population within this multi-island species' historical range on Kauai that is some distance away from the other critical habitat for this species, in order to avoid all recovery populations from being destroyed by one naturally occurring catastrophic event.

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 *Ischaemum byrone* critical habitat consists of one component. Coastal (east Maui and Molokai) (81 FR 17790-18110):

Ecosystem: Coastal. Elevation: <980 ft (<300 m). Annual precipitation: <20 in (<50 cm). Substrate: Well-drained, calcareous, talus slopes; dunes; weathered clay soils; ephemeral pools; mudflats. Canopy: Hibiscus, Myoporum, Santalum, Scaevola. Subcanopy: Gossypium, Sida, Vitex. Understory: Eragrostis, Jacquemontia, Lyceum, Nama, Sesuvium, Sporobolus, Vigna.

Habitat features that are essential for this species include, but are not limited to, coastal wet to dry shrubland, near the ocean, among rocks or on pahoe-hoe lava in cracks and holes.

Within these units, the currently known primary constituent elements of critical habitat include, but are not limited to, the habitat components provided by:

(i) Coastal shrubland near the ocean among rocks and seepy cliffs and containing one or more of the following associated native plant species: *Bidens* spp., *Chamaesyce celastroides*, *Fimbristylis cymosa*, *Lipochaeta succulenta*, *Lysimachia mauritiana*, or *Scaevola sericea*; and

(ii) Elevations between 0 and 159 m (0 and 523 ft).

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*, *Isodendron 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; Maui Wet Cliff—Units 6 and 7; and Molokai Montane 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.

The Service publishes this final rule acknowledging that they have incomplete information regarding many of the primary biological and physical requirements for these species. However, both the Act and the relevant court orders require the Service to proceed with designation at this time based on the best information available. As new information accrues, the Service may consider reevaluating the boundaries of areas that warrant critical habitat designation.

The following management actions are important in providing a conservation benefit to the species: feral ungulate control; wildfire management; nonnative plant control; rodent control; invertebrate pest control; maintenance of genetic material of the endangered and threatened plant species; propagation, reintroduction, and augmentation of existing populations into areas essential for the recovery of the species; ongoing management of the wild, outplanted, and augmented populations; maintenance of natural pollinators and pollinating systems, when known; habitat management and restoration in areas essential for the recovery of the species;

monitoring of the wild, outplanted, and augmented populations; rare plant surveys; and control of human activities/access.

The following management actions are important: Feral ungulate control; wildfire management; nonnative plant control; rodent control; invertebrate pest control; maintenance of genetic material of the endangered and threatened plant species; propagation, reintroduction, and augmentation of existing populations into areas deemed essential for the recovery of the species; ongoing management of the wild, outplanted, and augmented populations; maintenance of natural pollinators and pollinating systems, when known; habitat management and restoration in areas deemed essential for the recovery of the species; monitoring of the wild, outplanted, and augmented populations; rare plant surveys; and control of human activities/access.

Life History

Food/Nutrient Resources

Reproduction Narrative

Adult: Not available.

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Cliff, shrubland/chaparral (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Moist or wet areas (USFWS, 2010)

Geographic or Habitat Restraints or Barriers

Adult: Found at elevations between sea level and 190 meters (USFWS, 2010)

Environmental Specificity

Adult: Medium, with some key requirements (USFWS, 1996)

Habitat Narrative

Adult: *Ischaemum byrone* is commonly found in coastal shrublands, sea cliffs, talus slopes, and old lava flows. *Ischaemum byrone* usually grows in close proximity to the ocean, among rocks or frequently on moist or wet basalt cliffs in windward coastal dry shrubland at elevations between 0 and 190 meters (0 and 623 feet) with associated native plant species including *Bidens* spp. (*kookoolau*), *Fimbristylis cymosa* (*mauu aki aki*), and *Scaevola taccada* (*naupaka kahakai*) (USFWS 2003c). (USFWS, 1996; USFWS, 2010)

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends**Population Trends:**

Declining (USFWS, 2015)

Number of Populations:

~20 (USFWS, 2021c)

Population Size:

2,000 (USFWS, 2021c)

Population Narrative:

Currently, *Ischaemum byrone* is known from six or more populations on Molokai and Maui, totaling as many as several thousand individuals (USFWS 2012). On Molokai, *I. byrone* is relatively common from Wailau to Waiehu, and there are an estimated 200 individuals (Hawaii Biodiversity and Mapping Program 2008; H. Oppenheimer, Plant Extinction Prevention Program [PEPP], pers. comm. 2009). On East Maui, there are an unknown number of individuals at Pauwahu Point; 20 individuals in scattered patches at Mokuhiki islet; many individuals at Keawaiki Bay; and an unknown number of individuals at Kalahu Point, and at Waiohono Stream outlet and Muolea Point. These populations may total several thousands of individuals, depending on rainfall (Hawaii Biodiversity and Mapping Program 2008; H. Oppenheimer, pers. comm. 2010). On Hawaii Island at Hawaii Volcanoes National Park, there were 15 reintroduced individuals of *I. byrone* in 2010 (Hawaii Volcanoes National Park 2010). Overall, the numbers of individuals have decreased from the more than 5,000 wild individuals reported in the previous 5-year review to several thousand wild individuals in 2015. (USFWS, 2015)

Threats and Stressors

Stressor: Non-native plants (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: The most serious threat to *Ischaemum byrone* on Maui, Kauai, and the island of Hawaii is competition with invasive introduced plant species, particularly *Digitaria ciliaris* (Henry's crabgrass), *Ardisia elliptica* (shoebutton ardisia), and *Casuarina equisetifolia* (ironwood). Other introduced plants which compete with and displace *I. byrone* include *Aleurites moluccana* (kukui, candlenut), *Clidemia hirta* (Koster's curse), *Conyza bonariensis* (hairy horseweed), *Cynodon dactylon* (Bermuda grass), *Cyrtomium falcatum* (holly fern), *Emilia fosbergii* (Florida tasselflower), *Ficus microcarpa* (Chinese banyan), *Lantana camara* (lantana), *Nephrolepis multiflora* (NCN), *Plantago major* (broad leaved plantain), *Pluchea carolinensis* (Indian fleabane), *Phymatosorus grossus* (naturalized lauau), *Polypogon viridis* (beardgrass), *Pycnus polystachyos* ssp. *polystachyos* (bunchy sedge), and *Terminalia catappa* (false kamani) (Hawaii Biodiversity and Mapping Program 2009; Wood 2009). On Molokai, threats are invasive introduced plants including *Bryophyllum pinnatum* (airplant), *Ageratina adenophora* (sticky snakeroot), *Ageratina riparia* (spreading mist flower), *Digitaria ciliaris*, and *Rubus rosifolius* (thimbleberry) (Wood 2009). *Polypogon interruptus* (ditch polypogon) occupies the same habitat as *I. byrone* on Molokai and Maui, thus is displacing this species which grows in the same coastal habitat (Warshauer et al. 2009). (USFWS, 2010)

Stressor: Fire (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Fire may pose a threat in areas infested with invasive introduced grasses, provided enough fuel is present. (USFWS, 2010)

Stressor: Grazing and browsing by ungulates (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Other potential threats include grazing and browsing by goats (*Capra hircus*), cattle (*Bos taurus*), and axis deer (*Axis axis*). Disturbance from ungulates promotes the establishment of nonnative weed species. (USFWS, 2010)

Stressor: Residential development and landslides (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Some populations are also threatened by residential development and landslides (USFWS 2003c; Wood 2009). (USFWS, 2010)

Stressor: Climate change (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Climate change may also pose a threat to *I. byrnei*. However, current climate change models do not allow the Service to predict specifically what those effects, and their extent, would be for this species. (USFWS, 2010)

Stressor: Volcanism (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: On the island of Hawaii, another threat to *Ischaemum byrnei* is volcanism (volcanic activity). Lava flowing from Kilauea Volcano destroyed about 200 individuals west of Kamoamoa in 1992. A few individuals were rescued. (USFWS, 2010)

Recovery

Reclassification Criteria:

1. A total of five to seven populations of each taxon should be documented on the Big Island and at least one other island where it now occurs or occurred historically, if it is not endemic to the Big Island. (USFWS, 1996)
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived

perennials, and a minimum of 300 mature individuals per population for short-lived perennials. (USFWS, 1996)

3. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered. (USFWS, 1996)

Delisting Criteria:

1. A total of 8 to 10 populations of each taxon should be documented on the Big Island and at least 1 other island where they now occur or occurred historically, if it is not endemic to the Big Island. (USFWS, 1996)

2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials, and a minimum of 300 individuals per population for short-lived perennials. (USFWS, 1996)

3. Each population should persist at this level for a minimum of 5 consecutive years. (USFWS, 1996)

Recovery Actions:

- Protection of plants from ungulate (goat and deer) browsing, invasion of alien grasses, fire, and development are necessary for the recovery of this species. (USFWS, 1996)
- Efforts should be made to ensure that populations remain viable on each of the islands on which the species presently occurs. (USFWS, 1996)
- Assess whether current populations are naturally reproducing and increasing in number. (USFWS, 2010)
- Collect seeds from all populations on each island. (USFWS, 2010)
- Propagate for reintroduction, augmentation, and if possible, maintenance of ex situ plantings for genetic conservation. (USFWS, 2010)
- Store seed for future use. (USFWS, 2010)
- Survey historical locations for possible current occurrences. (USFWS, 2010)
- Work with Hawaii Division of Forestry, Wildlife and Hawaii State Parks, and other landowners to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species. (USFWS, 2010)
- Survey geographical and historical range for a current assessment of the species' status. (USFWS, 2015)
- Continue collection of genetic resources for storage, propagation, and reintroduction into protected suitable habitat within historical range. (USFWS, 2015)
- Evaluate genetic resources currently in storage to determine the need to place additional genetic resources in long-term storage due to this species' vulnerability to climate change. (USFWS, 2015)
- Maintain existing exclosures and monitor for potential incursions. (USFWS, 2015)
- Eradicate invasive introduced plants within ungulate exclosures and maintain exclosures free of invasive plants. (USFWS, 2015)
- Continue monitoring wild and reintroduced individuals. (USFWS, 2015)
- Develop and implement a fire management plan at the existing exclosures. (USFWS, 2015)

- Research the suitability of habitat for reintroducing this species in the future due to the impacts of climate change. Develop a strategy for preventing the extinction of this species if no suitable habitat is predicted in the future. (USFWS, 2015)
- Initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this taxon. (USFWS, 2015)

Conservation Measures and Best Management Practices:

- **New Management Actions:**
 - **Surveys and monitoring**—The Plant Extinction Prevention Program (PEPP) surveyed an occurrence on east Maui (PEPP 2021).
 - **Collection and propagation for genetic storage and reintroduction**—
 - o From 2016 to 2019, the Lyon Arboretum Seed Conservation Laboratory reported storage of 885 seeds representing one founder from Honopou (Maui) and 507 seeds representing one founder from Mū'olea Point Alaaula (Maui) (Lyon Arboretum 2020).
 - o In 2016, Haleakalā National Park (HALE NP) reported 200 seeds in storage representing 20 founders from 'Ōhe'o (HALE NP 2016). In 2019, 100 seeds and three propagules were in storage representing one founder from 'Ōhe'o (HALE NP 2019).
 - o In 2019, the Maui Nui Botanical Garden (MNBG) reported storage of 100 seeds representing seven founders from Mū'olea (Maui) (MNBG 2019).
 - o The National Tropical Botanical Garden (NTBG) has at least four plants in living collections at Kahanu Garden with more than 230 seeds collected from these plants (NTBG 2020).
 - o From 2016 to 2017, the Olinda Rare Plant Facility (ORPF) reported 16 plants in inventory representing two founders from Honopou (Maui) and one plant in inventory representing one founder from Kaupakulua (Maui) (ORPF 2020).
 - **Reintroduction and translocation**—
 - o HALE NP reported outplanting of 10 *Ischaemum byrsonia* to 'Ōhe'o in 2016 and an additional outplanting in 2020 to 'Ōhe'o and Kukui Bay (HALE NP 2016, 2020).
 - o In 2021, on the island of Hawai'i, Malama O Puna—Hawaiian Reforestation Program reported outplantings at Malama Ki (79 individuals total), MacKenzie State Park (16 individuals total), and at Nanawale Forest Reserve (90 individuals total), and observed several previous outplantings surviving (Kobsa 2021, in litt.). Some recruitment is observed but survival of the outplantings is challenged by drought. (USFWS, 2021b)
- **Recommendations for Future Actions:** Rats are reported as a potential threat to occurrences on Moloka'i; however, no significant new information regarding the species' biological status since the last 5-year review in 2015. Thus, the following recommendations for future actions are added or reiterated for the 5-year review for 2021.
 - **Surveys and inventories**—Survey current and historical range for a complete assessment of the species' status.
 - **Ungulate monitoring and control**—Continue to conduct ungulate control where possible to protect all occurrences from the impacts of feral ungulates, including browsing.
 - **Invasive plant monitoring and control**—Control established ecosystem-altering nonnative invasive plant species at all wild and reintroduced populations.
 - **Predator and herbivore monitoring and control**—Determine impacts from rats and develop and implement effective control measures for rodents at all *I. byrsonia* populations that are impacted.
 - **Fire monitoring and control**—Implement fire management plans for all populations on lands managed by the National Parks. Develop and implement fire management plans for all other populations.
 - **Captive propagation for genetic storage and reintroduction**—Continue collection of genetic resources for storage, propagation, and reintroduction into managed suitable habitat.
 - **Reintroduction and translocation**—Continue reintroductions and augmentations into suitable habitat within historical range in areas that are managed for known threats and to reduce impacts from stochastic events. Monitor reintroductions for successful recruitment.
 - **Human interaction monitoring and management**—Develop and implement effective measures to reduce the impacts of hikers and trail maintenance.
 - **Climate change adaptation strategy**—
 - o Research suitability of habitat for reintroduction of this species in the future due to impacts of climate change.
 - o Build resiliency and redundancy by increasing numbers of populations and individuals to reduce the

impacts of climate change. • Alliance and partnership development—Continue to work with partners and other land managers in planning and implementation of ecosystem-level restoration and management to benefit this taxon. (USFWS, 2021b)

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS. 1996. Big Island Plant Cluster Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. 80 pages + appendices.

U.S. Fish and Wildlife Service. 2016. Designation and Nondesignation of Critical Habitat on Molokai, Lanai, Maui, and Kahoolawe for 135 Species

Final Rule. 81 Federal Register 61. March 30, 2016. Pages 17790 - 18110. USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp.

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).

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants

Final Designation and Nondesignation of Critical Habitat for 46 Plant Species From the Island of Hawaii, HI. Final rule. 68 FR 39623 - 39722 (July 2, 2003).

Final Designation or Nondesignation of Critical Habitat for 95 Plant Species From the Islands of Kauai and Niihau, HI. Final rule. 68 FR 9116 - 9479 (February 27, 2003).

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

NatureServe. 2015. NatureServe Explorer: an online encyclopedia of life [web application]. Accessed August 2016

USFWS. 1996. Big Island Plant Cluster Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. 80 pages + appendices.

USFWS. 2010. *Ischaemum byrone* (no common name) 5-Year Review Short Form Summary. Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

USFWS. 2015. *Ischaemum byrone* (Hilo *Ischaemum*) 5-Year Review Short Form Summary. Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii. USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp.

USFWS. 2010. *Ischaemum byrone* (no common name) 5-Year Review Short Form Summary. Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

USFWS. 2015. *Ischaemum byrone* (Hilo *Ischaemum*) 5-Year Review Short Form Summary. Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii

USFWS. 2021b. 5-YEAR REVIEW. Short Form Summary. Species Reviewed: *Ischaemum byrone* (Hilo *Ischaemum*). 11 pp.

SPECIES ACCOUNT: *Joinvillea ascendens ascendens* (`ohe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/31/2016; Pacific Region (R1) (USFWS, 2017)

Physical Description

Joinvillea ascendens ssp. *ascendens* (ohe) is an erect perennial herb (USFWS, 2016).

Taxonomy

A member of the *joinvillea* family (*Joinvilleaceae*) (Wagner et al. 1999, p. 1450) (USFWS, 2016).

Historical Range

Historically, this subspecies was found in widely distributed occurrences on the islands of Kauai, Oahu, Molokai, Maui, and Hawaii Island (HBMP 2010). On Kauai, this subspecies was wide-ranging across the mountains and into coastal areas (HBMP 2010). On Oahu, this subspecies was known from the summit area of the Waianae Mountains, and ranged along the entire length of the Koolau Mountain range. On Molokai, this subspecies was known from the eastern half of the island ranging from Pelekunu Preserve and east to Halawa Valley. On west Maui, this subspecies occurred in the summit area, and on the northeastern side of east Maui it ranged from the Koolau FR to Kaapahu (Gates 2015, in litt.). On Hawaii Island, it occurred almost island-wide (USFWS, 2016).

Current Range

Found on the Hawaiian Islands of Kauai, Oahu, Molokai, Maui, and Hawaii. Kaua'i, O'ahu, Moloka'i, Maui, Hawai'i (extant) (USFWS, 2021). Island Distribution: Found on Kauai, Oahu, Molokai, Maui and Hawaii. (USFWS, 2021c) Distribution: Kaua'i, O'ahu, Moloka'i, Maui, Hawai'i (extant) (USFWS, 2022)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Lifespan

Adult: Short (USFWS, 2022)

Reproduction Narrative

Adult: Seedlings have rarely been observed in the wild. Seeds germinate in cultivation, but most die soon thereafter. It is uncertain if the apparent low seedling recruitment is typical of this subspecies, or if it is related to habitat disturbance.

Habitat Type

Adult: Terrestrial, riparian (USFWS, 2016)

Habitat Vegetation or Surface Water Classification

Adult: Wet to mesic *Metrosideros polymorpha*-*Acacia koa* lowland and montane forest (USFWS, 2016)

Dependencies on Specific Environmental Elements

Adult: Lowland mesic, lowland wet, montane wet, and montane mesic ecosystems (USFWS, 2016)

Geographic or Habitat Restraints or Barriers

Adult: Occurs from 1,000 to 4,300 ft. elevation (USFWS, 2016)

Habitat Narrative

Adult: The species is found in wet to mesic *Metrosideros polymorpha*-*Acacia koa* (ohia-koa) lowland and montane forests on the Hawaiian Islands of Kauai, Oahu, Molokai, Maui, and Hawaii. *Joinvillea ascendens* ssp. *ascendens* occurs in wet to mesic *Metrosideros polymorpha*-*Acacia koa* lowland and montane forest, and along intermittent streams, from 1,000 to 4,300 ft (305 to 1,300 m); in the lowland mesic (Kauai and Oahu), lowland wet (Oahu, Molokai, Maui, and Hawaii Island), montane wet (Kauai, Oahu, Molokai, Maui, and Hawaii Island), and montane mesic ecosystems (Kauai) (TNCH 2007; HBMP 2010) (USFWS, 2016).

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Not available

Number of Populations:

22 (USFWS, 2022)

Population Size:

100-201 (USFWS, 2022)

Population Narrative:

22 Populations. 100-201 individuals (USFWS, 2022)

Threats and Stressors

Stressor: Feral pigs, goats, and deer

Exposure: Habitat degradation and destruction

Response:

Consequence:

Narrative: This subspecies is threatened by destruction or modification of habitat by pigs (*Sus scrofa*), goats (*Capra hircus*), and deer (*Axis axis* and *Odocoileus hemionus*).

Stressor: Nonnative plants

Exposure: Competition

Response:

Consequence:

Narrative: This subspecies is threatened by nonnative plants that outcompete and displace native plants.

Stressor: Feral pigs, goats, deer, and rats

Exposure: Predation

Response:

Consequence:

Narrative: Herbivory by pigs, goats, deer, and rats (*Rattus exulans*, *R. norvegicus*, and *R. rattus*) is a likely threat to this species.

Stressor: Stochastic events (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Randomly occurring natural events, such as landslides, are a threat to the occurrences of *J. ascendens* ssp. *ascendens* on Kauai and Molokai (HBMP 2010). Fire is likely to be a threat to this subspecies in the drier areas of the Waianae Mountains of Oahu (HBMP 2010) (USFWS, 2016).

Stressor: Low reproduction (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: This subspecies is usually found as widely separated individuals. Seedlings have rarely been observed in the wild, and, although mature seeds germinate in cultivation, these seedlings also rarely survive to maturity. It is uncertain if this rarity of reproduction is typical, or if it is related to habitat disturbance, or possibly a lack of soil mycorrhizae (symbiotic relationship between fungi and plants) required for successful establishment (Wagner et al. 1999, p. 1451; Oppenheimer 2015, in litt.) (USFWS, 2016).

Stressor: Climate change (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Fortini et al. (2013, p. 76) found that, as environmental conditions are altered by climate change, *J. ascendens* ssp. *ascendens* is unlikely to tolerate or adapt to projected changes in temperature and moisture, and is unlikely to be able to move to areas with more suitable climatic conditions (USFWS, 2016).

Recovery

Reclassification Criteria:

Recovery Priority Number = 6 (USFWS, 2022) Number of populations and individuals needed for each plant species to meet the preventing extinction stage based on population and life history characteristics. Number of Populations = 3. Reproducing Individuals per population = 50 (USFWS, 2022). Number of populations and individuals needed for each plant species to meet the interim stage based on population and life history characteristics. Number of Populations = 3. Reproducing Individuals per population = 300 (USFWS, 2022). Number of population and

individuals of each plant species needed for downlisting based on population and life history characteristics. Number of Populations = 5. Reproducing Individuals per population = 500 (USFWS, 2022).

Delisting Criteria:

Number of populations and individuals of each plant species needed for delisting based on population and life history characteristics. Number of Populations = 10. Reproducing Individuals per population = 500 (USFWS, 2022).

Recovery Actions:

- Control feral pig, goats and deer through exclusion fencing.
- Control nonnative plants.
- Control rat populations.
- Propagate in ex situ collections
- Exclude feral pigs, goats, and deer by fencing.
- Control rats (eradication)
- Control nonnative plants

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** • Surveys and inventories—Continue to conduct surveys for *Joinvillea ascendens* subsp. *ascendens* in current and potentially suitable habitat. • Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect individuals from the negative impacts of feral ungulates. • Nonnative invasive plant management—Continue to implement nonnative plant control. • Fire management—Continue to develop and implement fire management plans for all populations. • Predation and herbivory control—Continue to construct and maintain fenced exclosures to protect individuals from the negative impacts of feral ungulates. Develop and implement control methods for rats. • Captive propagation for genetic storage and reintroduction—Continue collection and propagation efforts for maintenance of genetic stock. • Reintroduction and translocation—Continue to reintroduce individuals to managed suitable habitat to increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of habitat destruction, nonnative plant competition, predation, low numbers, and climate change. • Population biology research—Continue research regarding poor seed viability and failure of reintroductions. Conduct seed dispersal studies to better understand plant distribution and persistence of populations. Continue research on soil amendment. • Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change. • Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon. (USFWS, 2021b)
- **Current Management Actions:** • Surveys and monitoring— o The U.S. Army's Natural Resources Program (ANRP) monitors occurrences of *Joinvillea ascendens* subsp. *ascendens* in military training areas on O'ahu. o The Plant Extinction Prevention Program (PEPP) monitors individuals and conducts exclosure checks for occurrences on the islands of Hawai'i, Maui, and Kaua'i (PEPP 2010, 2011, 2012, 2014, 2016, 2018, 2020). • Ungulate control— o The ANRP maintains and monitors exclosures in the Wai'anae and Ko'olau ranges of O'ahu. o PEPP assisted the Division of Forestry and Wildlife (DOFAW) with construction of small exclosures at Laupāhoehoe and in the Pi'ihonua section of the Hilo Forest Reserve (Hawai'i) (PEPP 2009, 2018). o Exclosures are established at Hawai'i Volcanoes National Park (HAVO). o Individuals are within exclosures managed by the DOFAW at Laupāhoehoe

Natural Area Reserve (NAR) (Hawai'i), Hanawī NAR (east Maui), and at Miloli'i and the Alaka'i Wilderness Preserve (Kaua'i). o Maui Land and Pineapple Company (ML&P) manages and maintains exclosures at west Maui's Pu'u Kukui Watershed Preserve (ML&P 2010). o The National Tropical Botanical Garden manages fenced areas at Limahuli (Kaua'i). o Individuals are within fenced areas at The Nature Conservancy preserves at Kamakou (Moloka'i) and Wainiha (Kaua'i) (Dunbar-Co 2021, in litt.). o In 2005, the 'Ōla'a-Kilauea Partnership constructed an exclosure at Kūlani (Hawai'i) to protect an individual of *J. ascendens* subsp. *ascendens*. o The West Maui Mountains Watershed Partnership coordinates control of feral ungulates through installation of exclosures and strategic fencing on west Maui (ML&P 2010). • Nonnative plant control— o ML&P monitors and controls nonnative plants within the Pu'u Kukui Watershed Preserve (Maui) (ML&P 2010). o The 'Ōla'a-Kilauea Partnership conducts nonnative plant control within the exclosure at Kūlani (Hawai'i). • Fire management— o HAVO has developed and implements a fire management plan for the park (HAVO 2005/2007; NPS 2015 pp. xviii, 20, 36). o The ANRP, through its Invasive Plants Program, works to reduce fire fuel and maintains firebreaks, fuel breaks, and monitoring corridors within the Army's training areas on O'ahu (CEMML 2016, pp. 83–84). • Control of predation and herbivory by feral ungulates— o HAVO plans expansion of the exclosure at the Kahuku Unit of the park (NPS 2015, p. 38). o PEPP assisted landowners with construction of exclosures at Laupāhoehoe and in the Pi'ihonua section of the Hilo Forest Reserve (Hawai'i) (PEPP 2009, 2018). • Captive propagation for genetic storage and reintroduction— o PEPP collected fruit from wild plants at Mohihi-Wai'ālae (Kaua'i) in 2010, from Hakalau National Wildlife Refuge's (NWR) Kona Forest Unit (Hawai'i) in 2010, from Upper Waiākea (Hawai'i) in 2011 and 2012, from Awa'awapuhi and Mōhihi (Kaua'i) in 2016, from 'O'ōkala in 2017, and reported collection of seeds from wild populations at Kukui o Pa'e, 'Āinahou, and 'O'ōkala to Humu'ula (Hawai'i) in 2018 (PEPP 2010, 2012, 2016, 2017, 2018). o In 2020, the Lyon Arboretum Micropropagation Laboratory reported 149 explants in storage representing 1 founder from 'O'ōkala to Humu'ula (Hawai'i), 2 explants representing 1 founder from Honokōhau (Maui), 7 explants representing 1 founder from Pēpē'ōpae (Moloka'i), 87 explants representing 1 founder from Kalua'a (O'ahu), 11 explants representing 1 founder from Limahuli (Kaua'i), and 12 explants representing 3 founders from Mōhihi (Kaua'i) (Lyon Arboretum 2020). The Lyon Arboretum Seed Conservation Laboratory reported storage of 350 seeds representing 1 founder from 'O'ōkala to Humu'ula (Hawai'i), 1,213 seeds representing 1 founder from 'Ohe'o and 49 seeds representing 1 founder from Honolulu (Maui), 147 seeds representing 1 founder from Kamoku Flats (Moloka'i), 146 seeds from one founder at Kalua'a gulch (O'ahu) with an additional 177 seeds for research, and 927 seeds representing 3 founders from Mōhihi (Kaua'i) (Lyon Arboretum 2020). However, Chambers (2021, in litt., above) notes a likely short-lived storage behavior of this subspecies. o Between 2010 and 2019 on Hawai'i, the Volcano Rare Plant Facility (VRPF) reported propagation and storage of 35 plants representing 1 founder from Kohala; approximately 550 plants representing 8 founders from Laupāhoehoe; 5 plants representing 2 founders from Pu'u Maka'ala NAR; 29 plants representing 2 founders from Upper Waiākea; and 12 plants representing 2 founders from Wailuku (VRPF 2020). o The Olinda Rare Plant Facility (ORPF) reports storage of 43 potted plants representing at least 1 founder within 'Ohe'o on Maui (ORPF 2019). o In 2019, HAVO reported propagation and storage of 2 plants representing 1 founder from Pu'u Maka'ala-Ōla'a. o In 2019, DOFAW reported propagation at the Kaua'i MidElevation Nursery of 30 plants representing 1 founder at Miloli'i (Kaua'i), and an additional 130 plants at the Pua Loke propagation facility representing the same founder. o In 2020, the ANRP reported storage of three propagated plants representing on founder from Mākaha (O'ahu) and an uncounted number of seeds in storage from the same population. o In 2018, the Maui Nui Botanical Garden (MNBG) reported propagation of 43 plants representing an unknown number of founders from 'Ohe'o (Maui). o In 1992, the National Tropical Botanical Garden (NTBG) reported collection of 21 seeds

from at least one founder from the Waiʻanae mountains of Oʻahu; however, the viability of this collection is uncertain (NTBG 2020). In 1997, 10 seeds were stored representing an unknown number of individuals from Waikolu rim trail on Molokaʻi, and a collection in 2005 of 150 seeds representing an unknown number of individuals from Puʻu Aliʻi NAR (Molokaʻi). From 1991 to 2016, 727 seeds were collected and stored from an unknown number of founders from Awaʻawapuhi (Kauaʻi). In 2017, NTBG reported storage of 854 seeds representing 1 founder from Limahuli, Kauaʻi. In 2018, 20 seeds were collected from at least 1 founder at Koaiʻe (Kauaʻi) and in 2019 more than 1,200 seeds from Limahuli representing at least 1 founder (NTBG 2020).

- Reintroduction and translocation—
 - o HAVO outplanted individuals at the park in 2005; however, these plants did not survive (Pratt 2005, in litt.; HAVO 2020).
 - o Between 2010 and 2019, VRPF reported reintroductions (all on the island of Hawaiʻi) of 9 plants to Koaiʻe representing 1 founder from Puʻu Pili; 394 plants to Laupāhoehoe representing 7 founders from Laupāhoehoe; 104 plants to Puʻu Makaʻala NAR representing 2 founders from Puʻu Makaʻala NAR; and 73 plants to Puʻu Makaʻala NAR representing 3 founders from Upper Waiākea (VRPF 2020).
 - o Haleakalā National Park (NP) reported reintroduction of 62 plants within the park; however, there has been poor survival (Haleakalā NP 2020).
 - o In 2018, NTGB reported reintroduction of 3 plants (representing at least 1 founder from Koaiʻe, Kauaʻi) to their Southshore Garden as a living collection (NTBG 2020).
 - o PEPP reintroduced three plants to Hanawī NAR and nine plants to Waiheʻe, Maui, in 2020.
 - o From 2010 to 2015, DOFAW outplanted hundreds of plants Laupāhoehoe and Puʻu Makaʻala NARs (VRPF 2020).

Unfortunately, efforts to outplant at Laupāhoehoe have not been particularly successful. There were existing small outplants in 2020, but they have not grown substantially (VanDeMark 2021, in litt.). In contrast, the outplants at the Puʻu Makaʻala population have grown to large sizes and may be the only successful restoration population to date, with at least three large outplants nearing reproductive size (VanDeMark 2021, in litt.). The media used for this reintroduction was amended with soil from the source collection site; and the overall results seem promising (VanDeMark 2021, in litt.). Continued monitoring will suggest if cultivation efforts could be modified to increase success of propagation of this species.

- Population biology research—
 - o The Lyon Arboretum Seed Conservation Laboratory conducted seed viability testing; suggesting seeds have some dormancy and may be short-lived in storage and may be sensitive to drying conditions and maturation at time of collection (Chambers 2020, in litt.; Lyon Arboretum 2021, in litt.).
 - o PEPP assists propagation research with collections of soil from areas near wild plants for amendment to propagated plants (PEPP 2010). (USFWS, 2021b)

References

USFWS. 2014. Endangered and Threatened Wildlife and Plants

Review of Native Species That Are Candidates for Listing as Endangered or Threatened

Annual Notice of Findings on Resubmitted Petitions

Annual Description of Progress on Listing Actions

Proposed Rule. Federal Register 79(234), 72450-92497

USFWS. 2017. Environmental Conservation Online System (ECOS) – Species Profile.
<http://ecos.fws.gov/ecp0/>. Accessed March 2017

USFWS. 2016. Endangered and Threatened Wildlife and Plants

Endangered Status for 49 Species From the Hawaiian Islands. Final rule. 81 FR 67786 - 67860 (September 30, 2016). U.S. Fish and Wildlife Service. 2021. Draft recovery plan for 50 Hawaiian archipelago species. Portland, Oregon. xvi + 159 pp. USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp. USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

USFWS 2014. Endangered and Threatened Wildlife and Plants

Endangered Status for 49 Species From the Hawaiian Islands. Final rule. 81 FR 67786 - 67860 (September 30, 2016). USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

Endangered Status for 49 Species From the Hawaiian Islands. Final rule. 81 FR 67786 - 67860 (September 30, 2016). U.S. Fish and Wildlife Service. 2021. Draft recovery plan for 50 Hawaiian archipelago species. Portland, Oregon. xvi + 159 pp. USFWS. 2021b. *Joinvillea ascendens* subsp. *ascendens* ('ohe) 5-Year Review Summary and Evaluation. 34 pp. USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

Proposed Rule. Federal Register 79(234), 72450-92497.

Endangered Status for 49 Species From the Hawaiian Islands. Final rule. 81 FR 67786 - 67860 (September 30, 2016).

U.S. Fish and Wildlife Service. 2021. Draft recovery plan for 50 Hawaiian archipelago species. Portland, Oregon. xvi + 159 pp.

USFWS. 2022. Recovery plan for 50 Hawaiian Archipelago Species. Portland, Oregon. xvii + 166 pp. + Appendices.

USFWS. 2021b. *Joinvillea ascendens* subsp. *ascendens* ('ohe) 5-Year Review Summary and Evaluation. 34 pp.

SPECIES ACCOUNT: *Lilium occidentale* (Western lily)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/17/1994; Pacific Southwest (R8) (USFWS, 2017)

Physical Description

A perennial herb with a single stem that grows up to 1.8 m tall from an underground bulb. Narrow leaves grow singly or in whorls along the tall stem and 1-10, showy, nodding flowers bloom at the top of the stem from mid June to early August. The Flower petals are red or deep orange, strongly reflexed, with purple-spotted, yellow centers. (NatureServe, 2015)

Taxonomy

A member of the Liliaceae (lily family). There has been no change in taxonomic status of this species since it was described, although the existence of two forms of *Lilium occidentale* has been debated over the years. Past distinction of the varieties as “California” and “Oregon” appears in large part due to the fact that the largest population, which fits the “Oregon” form well, was not discovered in California until 1991. The best interpretation at this time seems to be that the variation seen between the forms often correlates with differences in environment, less often correlates with proximity to the similar congener species, and at the extreme southern end of the range (Table Bluff) is currently supported by defined genetic differences (USFWS, 2009).

Historical Range

Known from narrow strip along the coast in northern California and southern Oregon. Endemic to three counties. Historical occurrence in Coos County, Oregon and extant occurrences in Curry County, Oregon (NatureServe, 2015).

Current Range

Several extant occurrence in Humboldt County, California. California range extent covers about 146 sq mi in 3 main areas (NatureServe, 2015). It is restricted to a narrow strip along the immediate Pacific coast between Coos Bay, Oregon, and Eureka, California (USFWS, 2009) with a few new populations recently found in Coos Bay and Curry, Oregon (USFWS, 2019b).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual: self-pollination, asexual (USFWS, 2009)

Lifespan

Adult: ~25 years (USFWS, 2009)

Breeding Season

Adult: June - August (see physical description)

Key Resources Needed for Breeding

Adult: Open conditions, hummingbirds, insects (USFWS, 2009)

Reproduction Narrative

Adult: Reproductive plants require relatively open conditions (Bencie and Kalt 2007, Imper 1997, Schultz 1989). Like other lilies, *Lilium occidentale* has hermaphroditic flowers (producing both pollen and seeds). *Lilium occidentale* appears relatively unique within the genus in being able to produce abundant self-pollinated seed (Skinner 1988). Hummingbirds are the primary pollinator of *L. occidentale*, but bees and other insects may also transfer pollen (Skinner 1988, Schultz 1989). Reproductive plants usually produce 1-3, but up to 25 pendant flowers (Imper et al. 1987). Natural seed set in a sample of 35 capsules at Bastendorff Bog, Hauser Bog, and Shore Acres ranged from 0 to 204 seeds per capsule with a mean of 132 seeds (Schultz 1989). The species reproduces primarily by seed, but asexual reproduction is possible from detached bulb scales. In cultivation, plants may flower in as little as 3 years (Skinner 1988); in the wild plants may live for 25 years or more (Imper et al. 1987) (USFWS, 2009).

Habitat Type

Adult: Early-successional coastal habitat (USFWS, 2019)

Habitat Vegetation or Surface Water Classification

Adult: Sphagnum bog, margins of ephemeral ponds and small streams, coastal scrub and prairie (NatureServe, 2015); spruce forest (USFWS, 2009)

Dependencies on Specific Environmental Elements

Adult: Ocean fog, poorly drained soil (NatureServe, 2015); seasonal inundation, early successional habitat (USFWS, 2009); fire (USFWS, 1998)

Geographic or Habitat Restraints or Barriers

Adult: Coastal (NatureServe, 2015); occurs up to 300 ft. in elevation and up to 4 miles inland, dense vegetation reduces survivorship (USFWS, 2009)

Environmental Specificity

Adult: Very narrow (NatureServe, 2015)

Habitat Narrative

Adult: Inhabits Pacific coastal wetlands. Mostly restricted to the edges of early successional, wet sphagnum bogs and forest or thicket openings along the margins of ephemeral ponds and small streams. Also in coastal scrub and prairie, and other poorly drained soils near the ocean where fog is common. The environmental specificity is very narrow; it is only known from northwestern coastal wetlands (NatureServe, 2015). Although the species often occurs in fens that are flooded for periods in the winter and spring, the species does not appear to tolerate year-round inundation. Populations occur from just above sea level at Crescent City Marsh, to a maximum 300 feet in elevation, and from ocean-facing bluffs nearly 4 miles inland. With the exception of spruce forest, all of the habitats are early successional in development, which provides the necessary conditions for growth and reproduction. In the case of spruce forest, the dark, moist, acid understory conditions are well suited for establishment of *L. occidentale*, but the plant

remains vegetative. Very dense, tall shrub growth reduces reproduction and survivorship, and closure of the overstory canopy, although tolerated by young or small plants if it is moist, eventually may eliminate the population entirely (USFWS, 2009). Western lily populations appear to have been maintained in the past by occasional fires, at least at some sites in Oregon, and by grazing (USFWS, 1998).

Dispersal/Migration

Dispersal

Adult: Low (USFWS, 2009)

Dispersal/Migration Narrative

Adult: The genus has winged flat seeds that are wind-dispersed (NatureServe, 2015). Seeds are primarily dispersed by wind and gravity, mostly within a 13-foot radius (Skinner 1988) (USFWS, 2009).

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Number of Populations:

25 (USFWS, 2009; 2019)

Population Size:

9,000 - 10,000 individuals (NatureServe, 2015)

Adaptability:

Moderate (inferred from NatureServe, 2015)

Population Narrative:

Western Lily is amazingly resilient when left undisturbed. However, it is vulnerable due to its attractive flowers and occurrence in wet habitats. Several populations are historical and have not been refound, especially on Fields Landing and Arcata South quads in Humboldt Co. This species has experienced a long-term decline of 50-70%. Estimated total population of 9,000-10,000 individuals known with about 7,200 in California and a few thousand in Oregon, including recently discovered populations. About 40-50 small, widely separated populations known (Endangered Species Tech. Bull., 1992). 16-22 occurrences in California (NatureServe, 2015) with restoration efforts in Crescent City Marsh Outflow Restoration, in Del Norte County, CA, where the largest number of flowering plants of any population of *L. occidentale* occurs, expanding managed lands by 40 acres (USFWS, 2019). The 23 extant principle populations range in size from less than 0.1 acre to more than 6 acres, totaling about 40 acres of occupied habitat. Of the current 23 defined principle populations, 5 populations probably contain up to 50 plants; 8 likely range from 51-200 plants; 8 range from 201-600 plants, and 2 populations exceed 1,000 plants (USFWS, 2009). Restoration activities at Floras Lake State Natural Area in Curry County, Oregon have discovered additional *L. occidentale* in and adjacent to cleared areas, suggesting potential expansion of the population and population augmentation efforts have shown a survival rate of 19% of planted bulbs. Surveys in the Floras Lake State Natural Area indicate 47 and 50

individuals but without additional survey data, it is difficult to determine the overall trend in this area (USFWS, 2019). In 2017, a new population of 641 plants (300 in flower) was discovered on property adjacent to Floras Lake State Natural Area. Additionally, in 2013, a new population was discovered on private property on the South Slough estuary of Coos Bay in Coos County, OR and this population totaled 1,222 plants in 2018. In this location, the extent of viable habitat is defined by the extent of Blacklock soil with western Labrador tea (USFWS, 2019).

Threats and Stressors

Stressor: Habitat loss and modification (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: From the 1940's until the species was listed, conversion of habitat to cranberry farms, roads, and residential dwellings continued to eliminate *L. occidentale* and suitable habitat between Bandon and Port Orford, Oregon, an area that likely contained the greatest concentration of the species in Oregon more than 50 years ago (Ballantyne 1980, Schultz 1989). Cranberry agriculture continues to eliminate a large amount of suitable habitat each year, currently accounting for the largest loss of suitable habitat. Many of the smaller roadside occurrences cited when *Lilium occidentale* was listed could not be relocated (Imper, unpubl. data 2008), often due to driveway construction, cranberry development, grading, non-native species, or other developments overrunning the general area. A new factor since it was listed, which threatens the largest population of *L. occidentale* range-wide, is the prolonged flooding of the Crescent City Marsh (USFWS, 2009).

Stressor: Collection (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: *Lilium occidentale* is a very showy plant with great horticultural appeal. Horticultural collection was considered to be a significant threat at the time of listing, in part due to past publication of specific locations in professional journals. Ballantyne (1980) believed that repeated publication of the location of a California population in lily society yearbooks between 1934 and 1972 led to decimation of the population by lily growers and breeders. Given the frequent difficulty in detecting the majority of individuals within any one population, in most cases a single collection probably would not constitute a major threat. Nevertheless, there is good evidence that collection of plant parts has occurred frequently in the past, and such collections currently pose a threat to the smaller populations (USFWS, 2009).

Stressor: Predation (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Deer herbivory was identified as a threat for several Oregon and California populations at the time of listing, and continues to threaten, or at a minimum severely reduce the reproductive vigor of many populations. Even if not lethal, deer remove a considerable fraction of flowers and fruit, thus seriously reducing the reproductive output at many sites. In some cases small mammals, such as voles (*Microtus* spp.), have been observed browsing on

Lilium occidentale (Imper unpub. data 2008). However, measured impacts on *L. occidentale* from small mammal depredation overall appear relatively small compared to deer (Bencie and Kalt 2007; Imper, unpubl. data 2008). Grazing of leaves, buds, and flowers by Coleopteran (beetle) and Lepidopteran (butterfly, moth) larvae was observed in the past at one California site (Imper et al. 1987), but significant impact from these sources has not been reported or observed in recent years. Although cattle represent an obvious physical hazard to individual plants during the growth period, evidence indicates that its past categorical characterization as a major threat may be overstated. In contrast to deer and small mammals that are often very selective for *Lilium occidentale*, cattle often remove only the upper portion of the plant as a consequence of feeding on surrounding vegetation. Overall evidence suggests that while cattle grazing reduces individual reproductive potential, so long as there is adequate seed production and recruitment to offset mortality, that impact may be of little consequence compared to the benefits to its habitat (USFWS, 2009).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: In summary, the Endangered Species Act, in combination with the Clean Water Act, theoretically provide the greatest level of regulatory protection for *Lilium occidentale*. However, recent reinterpretation and the lack of enforcement of the Clean Water Act, particularly in Oregon, have resulted in little regulatory protection for the species. The Oregon Endangered Species Act, and in California, the California Coast Act and the California Environmental Quality Act, provide the greatest protection at the state level. However, protection under those laws is largely discretionary, and in Oregon there is essentially no prohibition of take on private property. The regulatory environment continues to be inadequate to protect this species, in large part due to a decline in the protection provided by the Clean Water Act (USFWS, 2009).

Stressor: Succession and nonnative plants (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: The most significant long-term threat to *Lilium occidentale* is competitive exclusion by shrubs and trees. Heightened competition is a consequence of the rapid and uninterrupted progression of ecological succession resulting from lack of disturbance (e.g., fire, grazing) for the past one to three decades for most sites. Although *L. occidentale* seedlings and juvenile plants can in some cases survive under closed canopy greater than 90 percent, the species is unable to successfully reproduce under those conditions. Therefore, rather than overgrazing constituting a threat, it is the lack of appropriate levels of grazing, or other adequate disturbance regime, that poses the greatest threat for many sites in both California and Oregon. Invasion by the non-native shrub *Ulex europaeus* (common gorse) into habitat for *Lilium occidentale* was identified as a threat in the past near Floras Lake State Park (Ballantyne 1980). Invasive species such as *U. europaeus*, *Cytisus scoparius* (scotch broom), *Rubus procerus* (himalayaberry) and others continue to threaten several sites across the range, including Hauser, Morrison, and Hultin sites under the BPA powerline, and Boak Lane and Harris State Park sites (Imper, unpubl. data 2008). In addition, *Phalaris arundinacea* (reed canarygrass), while not a current threat, is poised to invade wetlands across the range, the most worrisome being Crescent City Marsh (USFWS, 2009).

Stressor: Stochastic events/small population size (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Since many populations of *Lilium occidentale* continue to be very small (e.g., less than 50 flowering plants), loss of genetic diversity due to inbreeding and/or random genetic drift may continue to be a serious problem in some populations. Populations below an effective size of about 5,000 plants will generally maintain insufficient adaptive genetic variability for long-term adaptation to a changing environment, and those below 500 will experience accumulation of mildly deleterious mutations due to random genetic drift and inbreeding depression (Service 1998). Although this factor continues to be a threat due to the small population sizes, plants with genetic abnormalities observed during monitoring and other field work have not obviously increased since the species was listed (Imper, unpubl. data 2008) (USFWS, 2009).

Stressor: Climate change (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: It is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects. The species is restricted to habitats that provide adequate soil moisture, but are not inundated throughout the growing season. As a result, any change in the timing and amount of precipitation, or soil and air temperatures, could potentially render habitat unsuitable. In addition, the reproductive phenology of *L. occidentale* is closely linked to temperature. While the Service lacks adequate information to make accurate predictions regarding the effects of climate change on *L. occidentale*, we can say that the rarity of *L. occidentale*, combined with its relatively unique habitat and its demonstrated sensitivity to soil moisture conditions and temperature, suggest that it may be among the species affected by climate change. Another potential result of climate change is increased sea level, which potentially could impact the largest population of *L. occidentale* located at the Crescent City Marsh Wildlife Area (USFWS, 2009).

Recovery

Reclassification Criteria:

The western lily can be considered for downlisting to threatened when at least 20 viable populations are protected and managed to assure their continued existence. The 20 populations must be distributed among six recovery areas, with at least three in Area 1, five in Area 2, and four each in Areas 4, 5, and 6. For the purposes of this Recovery Plan, a viable population includes at least 1,000 flowering plants, and a population structure indicating stable or increasing plant numbers (USFWS, 2019).

Delisting Criteria:

Trends at each of the 20 populations are determined to be stable or increasing for a minimum of 25 years. Trend determination will be based on the number of flowering (reproductive) individuals present (USFWS, 2019a).

A minimum of 20 viable populations are appropriately managed through either long-term landowner agreements (e.g., stewardship plans, easements, or memorandums of agreements),

which identify maintenance of *Lilium occidentale* habitat as a primary management objective for the site or permanent conservation easement/covenant that commits both present and future landowners to the conservation of *Lilium occidentale* (USFWS, 2019a).

A monitoring plan to cover a minimum of 12 years post-delisting of *Lilium occidentale* has been approved by the Pacific Southwest Regional Director and is ready to be implemented at the time of delisting to ensure the ongoing conservation of the species and the continuing effectiveness of management actions (USFWS, 2019a).

Recovery Actions:

- On-site conservation that manages habitats to maintain habitat in appropriate seral stage (i.e., prevents or reverses encroachment by trees and shrubs) (USFWS, 1998).
- Establish seed bank and learn how to reintroduce or augment populations in the wild (USFWS, 1998).
- Enhance public awareness, understanding, and participation in western lily recovery (USFWS, 1998).
- Continue to support habitat restoration on state lands while encouraging, where feasible, a greater effort to expand occupied *L. occidentale* sites (USFWS, 2019b).
- The current grazing lease at Cape Blanco State Park should be managed to promote and maintain *L. occidentale* habitat. At Floras Lake State Natural Area, a broader, landscape level view should be taken in light of the widely distributed yet fragmented populations present and high availability of potentially suitable habitat (USFWS, 2019b).
- To support management decisions and recovery actions, repeatable, rigorous survey efforts should be conducted for each *L. occidentale* population. Survey schedules should be developed for each occupied site. Furthermore, data collection should follow established protocols, and data should be entered into a database housed by the Service (USFWS, 2019b).
- *L. occidentale* habitat should be conserved through conservation easements, and property acquisition should be pursued for populations on private lands that remain threatened by agriculture or development. Section 6 Non-traditional Recovery Grants may be used to secure conservation easements or acquire property, provided there is support from the Oregon Department of Agriculture and local land trust support. Obtaining endowment funds to cover land trust long-term expenses remains challenging, as does the challenge of negotiating a price for property acquisition (USFWS, 2019b).
- continue to work with the Bonneville Power Administration (BPA) to consult on actions occurring within BPA's right-of-ways that adversely affect *L. occidentale*. BPA's vegetation maintenance activities are credited with maintaining suitable habitat, yet much could be done to improve right-of-way management for *L. occidentale*. Examples include signage to inform powerline workers of sensitive habitats, training of workers in best management practices for those habitats, and better security to prevent trespass and damage by unauthorized vehicles (USFWS, 2019b).
- Hauser Bog – The Service should coordinate with the Oregon Departments of Agriculture and Transportation in order to: a) Implement negotiations with the two private landowners to allow construction of a fence along the east boundary of the habitat, and enable future vegetation management on their property in conjunction with the Department of Transportation's management of their Sensitive Management Area. If possible, secure a conservation easement or other legal agreement for protection and management; b)

Expand the recently completed mitigation area (Riley Ranch project) located south of the fen to include additional removal of tree overstory canopy around the wetland area and connecting it to the existing *Lilium occidentale* population (USFWS, 2009).

- Oregon State Parks – The Service should coordinate with the Oregon Department of Parks and Recreation to implement the following habitat restoration projects: a) Sunset Bay State Park: Continue manual clearing of the majority of the Bastendorff Bog parcel, and reconnect that population with former *L. occidentale*/Darlingtonia and/or former open Blacklock scrub habitat to the south and west of Bastendorff, near the sewer ponds and toward the park management office; b) Shore Acres State Park: Pursue restoration of a somewhat enlarged habitat area that includes, and connects the three existing colonies of *L. occidentale* south of the Simpson Gardens; c) Floras Lake State Park: Pursue restoration of large areas of habitat where suitable soils are known to occur, and which historically or currently supports *Lilium occidentale*, focused on two principle areas: the north end of the airport runway extending 300 feet or more north, east and west, and a second area starting at the main *L. occidentale* colony southwest of the hangers, and extending 500 feet or more north and west; d) Harris Beach State Park: Complete the fence around the full extent of the powerline site, and pursue restoration of the remainder of *Lilium occidentale* habitat there (USFWS, 2009).
- Point St George – The Service should coordinate with Del Norte County, and the Elk Valley and Smith River Rancherias to conduct an experimental burn in *Lilium occidentale* habitat, and then implement broad scale burn treatment of all suitable habitat on the Point (USFWS, 2009).
- Table Bluff Ecological Reserve – Continue research on the relationship between tree size and soil moisture, and *Lilium occidentale* mortality; subject to those results, implement broad scale removal of spruce within the occupied habitat as appropriate (USFWS, 2009).
- Crescent City Marsh: a) The Service, California Department of Transportation, California Coastal Commission, and the affected private landowner should move as quickly as possible to improve the drainage from Crescent City Marsh in order to prevent further decline in the largest population of *Lilium occidentale* range wide; b) CDFG should reintroduce livestock grazing as soon as possible into the Crescent City Marsh Wildlife Area (USFWS, 2009).
- Regulatory Enforcement – The Service should assist the USACE and the Oregon Division of State Lands to improve their enforcement of the Clean Water Act and the Oregon Fill and Removal Act, in order to stem the ongoing high losses of wetlands and potential *Lilium occidentale* habitat in Coos and Curry Counties (USFWS, 2009).
- Hauser Bog – The Service should coordinate with the Oregon Departments of Agriculture and Transportation in order to: a) Finalize a manual vegetation management plan for their portion of Hauser Bog, which ensures future treatment at a required interval (estimated 7-10 years); b) Negotiate access from the owners of wetland habitat directly across Highway 101, west of the Hauser Bog (formerly a part of Hauser Bog prior to highway construction), and conduct research necessary to determine suitability of that habitat for *L. occidentale*; c) Increase the propagated seedling bank at Shore Acres State Park nursery; after a minimum 3 years in the nursery, outplant a portion of the propagated plants to the mitigation area, and (subject to access by adjacent landowners) outplant to suitable locations west of Highway 101 (USFWS, 2009).
- Oregon State Parks – The Service should coordinate with the Oregon Department of Parks and Recreation in order to: a) Define management boundaries for *Lilium occidentale*, based on habitat requirements and practical limitations, that are adequate to attain one or more

recovery level populations at each of the five parks in which it occurs. Where feasible, these management areas should represent an expansion of the currently occupied habitat, and creation of suitable corridors of suitable habitat connecting the existing colonies of *L. occidentale*; b) Determine the management strategy most appropriate to each park (manual or mechanical control, controlled burns, grazing), and the estimated treatment interval necessary to maintain the population at the minimum recovery level size; review the feasibility for modifying trailsides maintenance methods to maximize suitable habitat for the plant (e.g., extended brush-cutting arm); c) Determine the necessary endowment funds or other funding mechanism needed to fund the periodic maintenance requirements in the future, and identify potential funding sources; d) Assist OPRD in developing specific *Lilium occidentale* conservation strategies for inclusion in each of the park management plans, which incorporate the above information; e) Cape Blanco State Park: Pursue restoration of formerly suitable habitat north and west of the existing population, and begin restoration of suitable habitat corridors connecting all of the high quality Blacklock scrub areas located generally west of the occupied habitat; in addition, at least a portion of the habitat within and surrounding the *Darlingtonia* fen at the south end of the park should support *L. occidentale*; that fen should be opened up and expanded through manual means, and if *L. occidentale* is not already present, the species introduced by seed and/or controlled propagation (USFWS, 2009).

- New River ACEC – The Bureau of Land Management should determine the extent of suitable habitat for *Lilium occidentale* within the ACEC and implement habitat restoration to include the nearby *Darlingtonia* fen (USFWS, 2009).
- Crescent City Marsh – CDFG should begin manual vegetation treatment within the Crescent City Marsh Wildlife Area, in a broad elevational zone surrounding the south portion of the marsh in order to restore suitable habitat at elevations above current summer high water levels (USFWS, 2009).
- General Landowner Agreements and Easements – The Service and both States should give increased focus to negotiating landowner agreements, and/or purchase of easements or fee title, in order to implement monitoring, protection and habitat restoration on all privately held populations, including in Oregon: properties under the BPA right-of-way, Webb/Sexton site, Boak Lane, Borax site, Fourmile Lane site, and in California: Hambro Industries, McMurray, Hiser and Christensen sites (USFWS, 2009).
- Coos County and Curry County Roads Departments – The Service should coordinate with these counties to facilitate roadside management along roads within suitable habitat for *Lilium occidentale*, which is conducive to the maintenance and spread of the species (USFWS, 2009).

References

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

USFWS. 2017. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed January 2017

USFWS 2009. *Lilium occidentale* (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arcata Field Office Arcata, California. USFWS. 2019a. Recovery Plan for Western Lily (*Lilium occidentale*). Draft Amendment 1. U.S. Fish and Wildlife Service, Pacific Southwest – Region 8, Sacramento, CA. 5 pp.

USFWS. 2019b. Five-Year Review Western Lily (*Lilium occidentale*). U.S. Fish and Wildlife Service Arcata Field Office. 5 pp.

USFWS 2009. *Lilium occidentale* (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arcata Field Office Arcata, California

U.S. Fish and Wildlife Service. 1998. Recovery Plan for the Endangered Western lily (*Lilium occidentale*). Portland, Oregon. 82 pp.

USFWS. 2019. Recovery Plan for Western Lily (*Lilium occidentale*). Draft Amendment 1. U.S. Fish and Wildlife Service, Pacific Southwest – Region 8, Sacramento, CA. 5 pp.

USFWS 2009. *Lilium occidentale* (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arcata Field Office Arcata, California.

USFWS. 2019. Five-Year Review Western Lily (*Lilium occidentale*). U.S. Fish and Wildlife Service Arcata Field Office. 5 pp.

USFWS. 2009. *Lilium occidentale* (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arcata Field Office Arcata, California.

USFWS. 2019a. Recovery Plan for Western Lily (*Lilium occidentale*). Draft Amendment 1. U.S. Fish and Wildlife Service, Pacific Southwest – Region 8, Sacramento, CA. 5 pp.

SPECIES ACCOUNT: *Lilium pardalinum* ssp. *pitkinense* (Pitkin Marsh lily)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/21/1997; Pacific Southwest (R8)

Physical Description

An herbaceous, rhizomatous (underground stem) perennial in the lily family (Liliaceae). The slender, erect stems reach 1 to 2 m (3 to 6 ft) in height. Leaves are yellow-green, up to 14 cm (5.5 in) long, and 1 to 2 cm (0.4 to 0.8 in) wide. The leaves are generally scattered along the stem, but in some plants occur in 2 or 3 whorls of 3 to 6 leaves near the middle of the stem. The inflorescence is a terminal raceme. The flowers are large, showy, and nodding. The petals, which are reflexed from the middle, are red at the outer edge changing to yellow at the center with small, deep maroon dots mostly within the yellow zone. Anthers (pollen-bearing part of the stamen) are purple-brown. The fruit is an elliptical capsule containing many rounded seeds (CDFG 1993b). The species flowers from June to July. *Lilium pardalinum* ssp. *pitkinense* is distinguished from *L. pardalinum* ssp. *pardalinum* by generally shorter petals and anthers. (USFWS, 1997)

Taxonomy

Lawrence Beane and Albert M. Vollmer first collected *Lilium pardalinum* ssp. *pitkinense* on July 20, 1954, in Sonoma County, California. Beane (1955) described the plant as *Lilium pitkinense*. Mark Skinner (1993) subsequently treated the plant as a subspecies of *L. pardalinum*. (USFWS, 1997). - In Kartesz (1994), *L. pitkinense* was synonymized under *L. pardalinum* ssp. *pardalinum*. In Kartesz (1999), *L. pardalinum* ssp. *pitkinense* (Beane & Vollmer) Skinner is treated as distinct but with the combination not formally published ("comb. nov. ined."), whereas M. Skinner in Hickman (1993), Skinner and Pavlik (1994), and Best et al. (1996) treat that subspecific name as if the combination has already been formally made (as required by the International Code of Botanical Nomenclature). According to the International Plant Name Index (August 2004), the name *Lilium pardalinum* Kellogg subsp. *pitkinense* (Beane & Vollmer) M.W. Skinner was published in Novon 12(2):255 in 2002 (NatureServe, 2015). A member of the lily family (Liliaceae) (USFWS, 2009).

Historical Range

See Current Range

Current Range

In California, in southern Sonoma County. (USFWS, 2019)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Asexual: vegetative (NatureServe, 2015); sexual (inferred from USFWS, 2009)

Lifespan

Adult: 2+ years (USFWS, 2009)

Breeding Season

Adult: June - July (USFWS, 2009)

Reproduction Narrative

Adult: This is a perennial plant. It flowers from June to July. In propagation, the species takes at least 3 years to mature into blooming plants from seed (B. Young, CNPS, pers. comm. 2009) (USFWS, 2009). It is also weakly clonal from an underground bulb (NatureServe, 2015).

Habitat Type

Adult: Wetland (NatureServe, 2015); riparian (USFWS, 2009)

Habitat Vegetation or Surface Water Classification

Adult: Freshwater marsh (NatureServe, 2015); fen, willow riparian woodland (USFWS, 2009)

Geographic or Habitat Restraints or Barriers

Adult: 115 - 200 ft. elevation (USFWS, 2009)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2009)

Habitat Narrative

Adult: This species grows only in marshy wetlands and edges of riparian areas that are 115 to 200 feet in elevation. The term "fen" is more accurate as its source of water is primarily from the ground and no bogs are found in California (Evens, in litt. 2008). Most of the occurrences in the southern marsh occur in the lower willow riparian woodland and riparian wetlands. At this locality, the species grows in soils that are seasonally saturated (Symonds, pers. Obs. 2008) (USFWS, 2009).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Declining (USFWS, 2019)

Number of Populations:

1 known, 2 others possible but status unknown (USFWS, 2019)

Population Narrative:

To date, there is a single, confirmed population of the Pitkin Marsh lily at Cunningham Marsh (CNDDDB 2018). This site is on shared, private land protected by a 19-acre conservation easement held by CDFW (Baye 2005). Members of the Milo Baker chapter of CNPS have been stewards of the conservation easement for over 25 years (B. Young, in litt. 2018). The two other occurrences are documented on two parcels of private land several miles north of Cunningham Marsh. Access for botanical surveys have been denied at these northern properties since the 1980s and it is unknown if these populations are still extant (CNDDDB 2018). (USFWS, 2019)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Loss and disturbance of habitat from proposed residential development and changes in hydrology is a current threat. The northern marsh has become drier due to the addition of wells and other construction (B. Guggolz, in litt. 1993). Drying of the wetland also encourages the spread of blackberries (*Rubus* sp.), which have become dominant in other parts of the marsh that have been drained (DFG 1993; B. Guggolz, in litt. 1993; CNDDDB 1996) (USFWS, 2009).

Stressor: Collection (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: The northern marsh occurrence was nearly extirpated from uncontrolled collection for horticultural uses in the early 1980s. Because of the past practices of collecting lilies for propagation for horticultural uses, material from Pitkin lilies and hybrids with other *Lilium pardalinum* species in the nursery trade is unsuitable for conservation purposes. Such material is unsuitable for conserving the wild strains because of the potential for genetic impurity through introgression with other lily species (USFWS, 2009).

Stressor: Nonnative plants (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Invasive, nonnative blackberries and grasses as well as native willow have encroached into the habitat of the species and appear to be increasing in density in recent years (Cooley, pers. Comm. 2008) (USFWS, 2009).

Stressor: Stochastic vegetation (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: The habitat for this species is extremely limited and isolated throughout its range. Losses from residential and agricultural uses have further contributed to the fragmentation and isolation of occurrences. Such occurrences may be highly susceptible to extirpation due to inbreeding depression (Gilpin and Soule 1988; Gooman 1987), the potential for catastrophic wildlife with drier marsh conditions, and the potential for further displacement from introduction

of previously unknown invasive vegetation (USFWS, 2009).

Stressor: Hybridization (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: An apparently natural hybrid of *Lilium pardalinum* and *L. maritimum* has been observed (Schwan, in litt. 2008; Skinner, in litt. 2008). The potential exists for horticultural varieties to be planted within the range of the wild populations (USFWS, 2009).

Stressor: Changing hydrology and climate (USFWS, 2019)

Exposure:

Response:

Consequence:

Narrative: The Pitkin Marsh lily is threatened by changing hydrology and climate in the region (USFWS 2009). Significant declines in Pitkin Marsh lily abundance appear to be somewhat correlated with reductions in early winter rainfall (K. Symonds, in litt. 2018a). The Pitkin Marsh lily thrive best when they are seasonally inundated by water (K. Symonds, pers. comm. 2018) and changes in hydrology appear to be affecting the community structure at Cunningham Marsh. There are several large pines (*Pinus* spp.) and oaks (*Quercus* spp.), which beneficially shade the understory of the marsh (Baye 2005). In recent years, several of these large trees have fallen, possibly due to low soil-moisture in the summer (K. Symonds, pers. comm. 2018). Falling trees could present a potential threat to the remaining Pitkin Marsh lilies; trunks and branches could physically crush individual plants. Additionally, opening the canopy and exposing the lilies to direct sunlight could prove fatal as well, as lilies seem to thrive in shade (K. Symonds, pers. comm. 2018). Additionally, if falling trees break enclosure fencing, the threat from deer browsing would increase. (USFWS, 2019)

Stressor: Random events (USFWS, 2019)

Exposure:

Response:

Consequence:

Narrative: Due to its extremely narrow range and specific habitat requirements, the Pitkin Marsh lily is susceptible to random, environmental effects such as tree felling, fire, changes in climate, etc. Although many threats remain the same, others have intensified since they were last assessed (USFWS 2009). However, our understanding of the major threats influencing the viability of the Pitkin Marsh lily has not changed dramatically since the previous status review (USFWS 2009). (USFWS, 2019)

Stressor: Small mammal browsing (USFWS, 2019)

Exposure:

Response:

Consequence:

Narrative: During the 2009 five-year review for the species, browsing by ungulates and urban development were no longer considered threats acting on the species, as all known, remaining individuals were protected by fenced enclosures at Cunningham Marsh. However, the implementation of conservation measures and the amount of available funding have lapsed for the Cunningham Marsh site since 2009, and it is possible that ungulate browsing at this location

could occur if fencing is not maintained and/or the species occurs outside of the exclosures. Recent abundance surveys have seen herbivory on lilies increase within exclosures (K. Symonds, pers. comm. 2018) as evidenced by the increase of stems without seed capsules (Appendix C). The fences protecting lily populations are composed of large-gauge wire mesh. Rabbits or small rodents can access the exclosed area through the mesh or by burrowing underneath it, and are likely the cause of increased browsing (K. Symonds, pers. comm. 2018). The CNPS in Sacramento, California, has applied for a grant to install small-mesh fencing on the exclosures at Cunningham Marsh (B. Young, in litt 2018). Until this happens, small-mammal browsing remains a significant threat to the viability of the Pitkin Marsh lily (USFWS, 2019).

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Recovery Priority Number: 6C

Delisting Criteria:

Not available - this species does not have a recovery plan.

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Increase the size of existing protected habitat through conservation easement or, preferable, fee-title acquisition. Manage these properties to protect and enhance the habitat for and the occurrences of this species and other historically co-occurring rare and unique plant taxa. (USFWS, 2009)
- Evaluate the genetic status of the species to determine the validity or reaffirm the uniqueness of this taxon (USFWS, 2009).
- Prepare and publish a draft recovery plan and ultimately finalize the recovery plan for the species (USFWS, 2009).
- Work with willing landowners in or near historical occurrences to develop access agreements to conduct surveys, monitoring, and habitat enhancements, and provide them assistance to minimize their indirect land use impacts on occupied habitat (USFWS, 2009).
- Monitor and continue adaptive management of existing protected areas to control invasive vegetation, address excess sediment and nutrients in the marshes, and encourage growth of listed species and co-occurring rare plant taxa within their historical occurrences (USFWS, 2009).
- Continue to maintain viable, protected seed collection. Ensure sufficient seeds exist, preferably in more than one repository, to maintain genetic heterogeneity. For long term preservation of genetic diversity, and given *L. pardalinum* is a clonal perennial that regenerates from bulb scales, consideration should be given to having a clone bank as a supplement or alternative to seed storage. A clone bank would be a low-maintenance partial shade garden derived from either seed or bulb scales of the original occurrence (USFWS, 2009).
- Manage invasive species. Invasive, non-native plants currently grow in the exclosures protecting the Pitkin Marsh lily (K. Symonds, pers. comm. 2018). Himalayan blackberry (*Rubus armeniacus*) and velvet grass (*Holcus lanthus*) grow densely, outcompeting the Pitkin

Marsh lily for light and space (Baye 2005). Continuous management of both species will allow Pitkin Marsh lily numbers to rebound. (USFWS, 2019)

- Propagation and out-planting. Pitkin Marsh lilies mature after three growing seasons (Baye 2005). In 2009, mature plants were out-planted in exclosures at Cunningham Marsh. Today, only a few of the out-plantings survive. More propagation efforts would increase our ability to establish Pitkin Marsh lilies at additional locations and to supplement extant colonies. These techniques might be essential to ensure the long-term viability of the species. (USFWS, 2019)
- Maintenance and construction of browsing exclosures. There are currently 10 exclosures protecting Pitkin Marsh lily colonies from browsing by ungulates. However, many do not appear to contain Pitkin Marsh lilies any longer. Moving these structures, and/or establishing new ones along with refined propagation and out-planting techniques might be needed to establish new colonies and/or populations, which would increase redundancy for this species. (USFWS, 2019)
- Installation of small-mesh fencing. In recent years, browsing by small-mammals within exclosures has significantly decreased the number of reproducing Pitkin Marsh lilies (K. Symonds, pers. comm. 2018; Appendix B). The California Native Plant Society has applied for a grant to install small-mesh fencing, which would protect Pitkin Marsh lilies from browsing. This action could significantly increase the viability of the Pitkin Marsh lily in the near-future. (USFWS, 2019)

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** • Conduct genetic analyses to better understand the species' taxonomy. Further genetic analyses may help resolve Pitkin Marsh lily's relationship with other *Lilium pardalinum* subspecies and potential hybrid origin. Additionally, specific studies of population genetics at Pitkin Marsh lily sites and of lilies in Lower Pitkin Marsh would help confirm the species genetic diversity, abundance, and distribution. • Encourage conservation and coordination between private landowners to gain access to the Pitkin Marsh populations and conduct coordinated surveys. Gaining access to the private lands where no surveying and monitoring has occurred will provide more information on the species. It is also possible that there are additional populations that exist on private properties that we are currently unaware of, and that with outreach and/or community awareness, willing landowners may come forward that are aware of the plants' existence. • Continue surveys of the Cunningham Marsh population. Continued surveys of the Cunningham Marsh population will assist with assessing status and trends for the species. Additional population data will help inform strategies to preserve and enhance populations. • Continue management at Cunningham Marsh through coordination with partners including the Plant Society and the Laguna Foundation. Continued management at Cunningham Marsh, including fencing repair when necessary and removal of non-native plant species, is necessary to maintain and increase resiliency of this population. • Collect and maintain a viable, protected seed collection from all populations and conduct seed germination tests on previously collected seeds. Pitkin Marsh lily seeds are currently stored at Rae Selling Berry Seed Bank, the California Botanic Garden, and the University of California Botanical Garden, which were collected in 1990, 2016, and 2019, respectively. Collecting a suitable seed bank can contribute to recovery strategies, such as outplanting to supplement existing populations or to establish new populations. • Using the results of the genetic analysis described above, develop a propagation and outplanting plan for Pitkin Marsh lily. Begin outplanting Pitkin Marsh lilies to establish additional populations within the historical range of the species and augment existing populations. Implement monitoring and management to ensure these populations become established to increase ecological representation.

- Continue efforts to control and contain *Phytophthora* to limit the spread of the pathogen within and outside of Pitkin Marsh. In addition, research on more effective treatment options and control techniques is needed (USFWS, 2024).

References

USFWS. 1997. Determination of Endangered Status for Nine Plants from the Grasslands or Mesic Areas of the Central Coast of California. Final Rule. 62 FR 55791 - 55808 (October 22, 1997)

USFWS. 2019. Pitkin Marsh lily (*Lilium pardalinum* ssp. *pitkinense*), 5-Year Review. U.S. Fish and Wildlife Service. Sacramento, California. 8 pp. May 2, 2019.
https://ecos.fws.gov/docs/five_year_review/doc6011.pdf

USFWS. 2009. *Carex albida* (White sedge), *Lilium pardalinum* ssp. *pitkinense* (Pitkin marsh lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento, California. 38 pp. August 17, 2009. https://ecos.fws.gov/docs/five_year_review/doc2548.pdf

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

USFWS. 2009. *Carex albida* (White sedge), *Lilium pardalinum* ssp. *pitkinense* (Pitkin marsh lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento, California. 38 pp. August 17, 2009. https://ecos.fws.gov/docs/five_year_review/doc2548.pdf

USFWS. 2009. *Carex albida* (White sedge) *Lilium pardalinum* ssp. *Pitkinense* (Pitkin marsh lily) 5-Year Review: Summary and Evaluation. U.S. fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California.

USFWS. 2019. Pitkin Marsh lily (*Lilium pardalinum* ssp. *pitkinense*), 5-Year Review. U.S. Fish and Wildlife Service. Sacramento, California. 8 pp. May 2, 2019.
https://ecos.fws.gov/docs/five_year_review/doc6011.pdf

USFWS. 2024. 5-YEAR REVIEW Pitkin Marsh Lily (*Lilium pardalinum* ssp. *pitkinense*). Sacramento Fish and Wildlife Office. Sacramento, CA. 9 pp.

SPECIES ACCOUNT: *Nervilia jacksoniae* (No common name)

Species Taxonomic and Listing Information

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

Physical Description

An orchid (USFWS, 2015).

Taxonomy

A member of the orchid family (Orchidaceae) (USFWS, 2015).

Historical Range

Historically, *N. jacksoniae* occurred on the islands of Guam and Rota, from northern to southern Guam and on the Sabana region of Rota (Rinehart and Fosberg 1991, pp. 81–85; Raulerson and Rinehart 1992, p. 118; Costion and Lorence 2012, p. 67) (USFWS, 2015).

Current Range

It currently occurs on Guam and Rota (Mariana Islands) (USFWS, 2015). Distribution: Guam, Rota (USFWS, 2020b).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Lifespan

Adult: Short (USFWS,2023)

Reproduction Narrative

Adult: Not available

Habitat Type

Adult: Terrestrial (USFW, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Pandanus forest (USFWS, 2015)

Spatial Arrangements of the Population

Adult: Patchy (USFWS, 2015)

Environmental Specificity

Adult: Narrow (USFWS, 2015)

Habitat Narrative

Adult: It occurs in the forest ecosystem. This species can occur deep within forested areas in the Sabana region that are difficult to access due to extremely rugged karst and thick Pandanus forest. This species occurs in a patchy distribution, in specialized niche habitat (Harrington et al. 2015, in litt.) (USFWS, 2015).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Not available

Species Trends:

Decreasing (USFWS, 2015)

Number of Populations:

8 (USFWS, 2023)

Population Size:

708 (USFWS, 2023)

Population Narrative:

Currently, there are approximately 15 occurrences totaling at least 520 individuals. On Guam, *N. jacksoniae* is known from 2 occurrences totaling fewer than 200 individuals (M and E Pacific, Inc. 1998, p. 58; Grimm 2012, in litt.; McConnell 2012, pers. comm.). On Rota, *N. jacksoniae* is known from 13 scattered occurrences totaling at least 320 individuals in the forest ecosystem (Rinehart and Fosberg 1991, pp. 81–85; Raulerson and Rinehart 1992, p. 118; Costion and Lorence 2012, p. 67; CPH 2012e—Online Herbarium Database; GBIF 2012c—Online Herbarium Database; McConnell 2012, pers. comm.; Zarones et al. 2015d, in litt.). Data indicate that populations of *N. jacksoniae* are decreasing from their initial abundance observed on Guam (Rinehart and Fosberg 1991, p. 84; Cook 2012, in litt.; Harrington et al. 2012, in litt.) (USFWS, 2015). There are only eight known populations of *Nervilia jacksoniae* with an estimated overall population size of 708 individuals (388 on Guam and 320 on Rota). One of the three populations on Guam is planned to be protected by ungulate-exclusion fencing, but none of the five populations of *N. jacksoniae* on Rota are protected from ungulates or other threats to individual plants and their habitat. The GPEPP nursery has successfully propagated tubers of the plant, but not to reproduction. The plant's vegetative reproduction complicates estimates of the number of individuals (USFWS, 2020).

Threats and Stressors

Stressor: Development, military training, and urbanization (USFWS, 2015).

Exposure:

Response:

Consequence:

Narrative: In their 2015 Final SEIS ([http:// guambuildupeis.us/](http://guambuildupeis.us/)) (see “Historical and Ongoing Human Impacts,” above), the U.S. Department of Navy states that approximately 5,000 Marines will be relocated from Okinawa to Guam, accompanied by approximately 1,300 dependents, with a concurrent introduction of support staff and development of infrastructure, and increased use of resources such as water (Berger et al. 2005, p. 347; JGPO– NavFac, Pacific 2015, p. ES–3). The current preferred alternative sites on Guam for cantonment and live-fire training include the Naval Computer and Telecommunications Station Finegayan and Northwest Field on Andersen AFB, where this species occurs. In November 2007, the people of Rota voted to legalize casino gambling to increase tourism, and two development projects have been proposed. development around and within forested areas on Rota will also directly impact the forest habitat and individuals of this species (USFWS, 2015).

Stressor: Feral ungulates (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: Feral pigs are extremely destructive and have both direct and indirect impacts on native plant communities. While rooting in the earth in search of invertebrates and plant material, pigs directly impact native plants by disturbing and destroying vegetative cover, and trampling plants and seedlings. Several herds of Asiatic water buffalo or carabao roam southern Guam and the Naval Magazine area, and cause damage to the forest ecosystem that supports this species (USFWS, 2015).

Stressor: Fire (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: Fire is a human-exacerbated threat to native species and native ecosystems throughout the Mariana Islands, particularly on the island of Guam. Fire can destroy dormant seeds of native species as well as plants themselves, even in steep or inaccessible areas. Successive fires that burn farther and farther into native habitat destroy native plants and remove habitat for native species by altering microclimate conditions to those favorable to alien plants (USFWS, 2015).

Stressor: Climate change (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: On a global scale, sea level is rising as a result of thermal expansion of warming ocean water; the melting of ice sheets, glaciers, and ice caps; and the addition of water from terrestrial systems (Climate Institute 2011, in litt.). This species occurs close to the coast in the adjacent forest ecosystem at or near sea-level and may be negatively impacted by sea-level rise and coastal inundation due to climate change (USFWS, 2015).

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Recovery Priority Number: 8

Delisting Criteria:

Minimum Number of Stable Populations: 10. Reproducing Individuals / Population: 500 (USFWS, 2023).

Recovery Actions:

- Not available - this species does not have a recovery plan.
- A conservation project on Rota, administered through the Water and Environmental Research Institute of the Western Pacific at the University of Guam, is aimed to analyze the island's hydrology, with the ultimate goal of protection of the Sabana Watershed and Talakhaya Springs (Keel et al. 2007, pp. 5, 22–23). Erosion control, revegetation, and water source preservation conducted as part of this project may provide protection to this species (USFWS, 2015).

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** • Determine population status, current distribution, and availability of sites for plant conservation—Determine the distribution and number of all individuals on each island. Assess the availability of sites for long-term conservation of plant populations. Assess the status and threats to each population to inform prioritization of conservation effort. • Conduct research to clarify life history information and threats to the populations and their habitat—Conduct research to determine the best way to control the brown treesnake, rodents, and invasive invertebrates. Assess development and land designation and zoning threats to conservation of habitat needed for recovery. • Ungulate monitoring and control—Construct and maintain fenced exclosures to protect wild and reintroduced individuals from the negative impacts of feral ungulates. • Invasive plant monitoring and control—Control ecosystem-altering nonnative invasive plant species and those that compete with *Nervilia jacksoniae* at all populations. Protect all populations and native forest habitat on Guam and Rota from wildfire. • Captive propagation for genetic storage and reintroduction—Continue to collect propagative materials for storage and reintroduction. • Reintroduction and translocation—Develop populations via reintroductions to suitable sites and increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of disturbance. • Develop regulations and policy essential to recover the species and their habitats—Encourage the development of legislation to ensure protection of the listed species under Commonwealth or Territorial law. Develop and support the implementation of biosecurity plans to prevent the influx of new pests and invasive species into the Territory and inter-island movement of pests and invasive species. Develop and implement laws and policies to prevent wildfire from burning native forest. • Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon. (USFWS, 2020)
- **Current Management Actions:** • Surveys and inventories – • The CNMI Department of Land and Natural Resources have conducted surveys in the past on Rota of *Nervilia jacksoniae* (Zarones et al., 2015). • Joint Region Marianas (JRM) surveyed for ESA-listed species, including *N. jacksoniae*, at the Tarague Triangle, MSA Igloos, THAAD, and other projects to document locations and estimate population densities in sites that are proposed for ungulate exclusion and forest restoration (JRM 2019 and 2020). • Captive propagation for genetic storage and reintroduction – • The Guam Plant Extinction Prevention Program (GPEPP) has propagated *Nervilia jacksoniae* in the nursery. They have brought tubers into cultivation, which has yielded the production of leaves, but not flowers, before

tubers became dormant again. They report that the species is challenging to study due to the long dormant period, which is also noted throughout the literature on *Nervilia* species (GPEPP 2018). • Habitat protection – • One of the *Nervilia jacksoniae* populations in the Naval Munition Station in southern Guam is within the boundaries of an area the Department of Navy is proposing to fence and exclude ungulates (UOG 2019, Figure 2c). Additional fenced ungulate exclosures are being constructed on Naval Munition Station, and some of these may contain *N. jacksoniae*. The purpose of these exclosures is to restore native forest habitat. These exclosures could provide quality habitat for existing or reintroduced *N. jacksoniae* populations. • A major biosecurity focus within the Mariana Islands is preventing the spread of BTS to the CNMI from Guam. Federal agencies support local capacity both in Guam and the CNMI. Efforts include inspection of all arriving cargo from Guam to the CNMI by BTS detection dogs as well as specialized trapping around all major ports of entry. The Department of Agriculture, Wildlife Services, in coordination with the National Wildlife Research Center (NWRC), U.S. DoD Environmental Security Technology Certification Program, and the Department of Interior-Office of Insular Affairs (U.S. Geological Survey, USFWS), are using aerial applications of acetaminophen to suppress BTS over forested areas in AAFB (Dorr, et al. 2016, in litt.; Phillips 2014, in litt; BTSTWG 2015, entire). In addition, repeated and sustained applications could drastically reduce BTS abundance on a landscape scale (Siers, et al. 2018, in litt.). • An island-wide Habitat Conservation Plan for Guam, that would provide a collaborative and comprehensive approach to endangered and threatened species conservation on non-federal lands, is beginning to be developed (USFWS 2020). • A 2020 Memorandum of Understanding between JRM and the USFWS outlined a mutual understanding regarding the intentions and future considerations of a Department of Defense Readiness and Environmental Protection Integration Initiative (REPI) to address conservation of upland vegetation communities (DON and USFWS 2020). • Suitable habitat for *Nervilia jacksoniae* occurs at the Guam National Wildlife Refuge (NWR), Ritidian unit. Although *N. jacksoniae* is not known to occur at Ritidian Point, the Refuge unit receives some protections from invasive animals and plants, so if *N. jacksoniae* were propagated and planted there, the conservation status of the species may be improved. (USFWS, 2020)

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS 2015. Endangered and Threatened Wildlife and Plants

Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497. USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497. USFWS. 2023. Recovery Plan for 23 Species in the Mariana Islands. Portland, Oregon. xiv+102 pp.

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497. USFWS. 2020. *Nervilia jacksoniae*. 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. 25 pp. USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices. USFWS. 2023. Recovery Plan for 23 Species in the Mariana Islands. Portland, Oregon. xiv+102 pp.

USFWS. 2015. Endangered and Threatened Wildlife and Plants

Final Rule. 80 Federal Register 190. October 1, 2015. Pages 59423 - 59497.

USFWS. 2023. Recovery Plan for 23 Species in the Mariana Islands. Portland, Oregon. xiv+102 pp.

USFWS. 2020. *Nervilia jacksoniae*. 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. 25 pp.

SPECIES ACCOUNT: *Nolina brittoniana* (Britton's beargrass)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4) (USFWS, 2015) 4/27/1993

Physical Description

Perennial herb with thick underground rhizomes (stems). The long-lived, slender, arching leaves are 1-2 m [3-6 ft] long, 6-13 mm [0.2-0.5 in] wide, forming a rosette. The flowering stem grows at least 2 m (6 ft) high in April. The branches of its panicle are covered with many small white six-parted flowers. Plants are subdioecious (i.e. male and female flowers on separate plants). The plant is conspicuous when in flower. The fruits are triangular in cross section and are symmetrical (USFWS, 1996).

Taxonomy

The genus *Nolina*, which belongs to the agave family. Also referred to as scrub beargrass (USFWS, 1996)

Historical Range

See current range/distribution.

Current Range

Florida Central Ridge endemic, found in Hardee, Hernando, Highlands, Lake, Orange, Osceola, Polk, and Marion counties. (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Abiotic and Biotic (NatureServe, 2015)

Breeding Season

Adult: *Nolina brittoniana* flowers from early March to mid-May (NatureServe, 2015).

Reproduction Narrative

Adult: *Nolina brittoniana* flowers from early March to mid-May. Thorne (1965) reported that the male plants shed pollen in early morning several hours after their flowers have opened. These are moderately fragrant, especially during the cooler evening hours. The pistillate flowers exude nectar about 24 hours after opening during the night or predawn hours. A stigmatic "droplet" signals the flowers' receptiveness to pollination. Thorne did not state what the pollinator is, but moths are known to pollinate the related genus *Yucca* (Baker, 1938; USDA Forest Service, 1974). The fruits mature from July to October and are evidently wind disseminated because of their inflated capsules (Thorne, 1965). The life history of the related genus *Yucca* has been studied in the Southwestern U.S. Seedling plants begin flowering when about 5-6 years old under

favorable environmental conditions. Pollination seldom occurs without the aid of the female yucca moth which gathers the pollen and places it in the stigmatic tube. (The inflorescence shoots of capsular yuccas are highly palatable to wildlife and livestock.) Their seeds have some degree of hardseededness and germination can be speeded up by soaking them in water at room temperature for at least 24 hours before sowing. Germination usually begins in 1 to 2 weeks but may continue for 2 to 3 years. Most plants in botanical gardens have been transplanted from the wild (USDA Forest Service, 1974).; *Nolina brittoniana* is a fairly rare plant which occupies a larger habitat range than the strict scrub endemics. It is widely scattered and not abundant anywhere - populations usually occurring as small colonies of several isolated plants which frequently form clumps by underground suckering. Thorne (1965) studied *Nolina* in the field during the early 1960's and stated that vegetative reproduction accounts for the bulk of many populations. He often saw ten or more individuals forming a clump several feet in diameter - these were recognized as clones by the simultaneous elongation of their inflorescences in the spring. He observed populations ranging from the normal several hundred specimens on a few acres to sites having many thousand plants over several square miles (these larger populations are no longer extant). He thought that the usual condition of several plants growing in apparent isolation was the result of a more extensive population succumbing to the competition pressure of succession. *Nolina* is entirely dependent on fire or some other mechanism to maintain an open successional stage in the scrub or sandhill. Fire exclusion has allowed taller plants to shade it out of otherwise suitable habitat. Thorne (1965) observed that leaves of *Nolina* were much shorter (often with burnt tips) in areas subjected to frequent burning. These scarcely flammable green leaves protect the central stem from fire damage (Ward, 1979).; Apomictic; ASEXUAL; Monoecious; Predominantly outcrossing; SEXUAL; Vegetative spread; ABIOTIC; Wind; BIOTIC; Lepidoptera; (NatureServe, 2015)

Habitat Type

Adult: Sandhills (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: Deep, fine-textured, well-drained sands of sand pine-evergreen oak scrub or longleaf pine-turkey oak sandhill. Other associated plants include *Serenoa repens*, *Sabal etonia*, *Lyonia ferruginea*, *Ceratiola ericoides*, *Palafoxia feayi*, *Aristida stricta*, etc. (Florida Natural Areas Inventory) (NatureServe, 2015). High ecological integrity of the population and site fidelity as well as low tolerance ranges are inferred based on the specific habitat requirements of this species.

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: The fruits mature from July to October and are evidently wind disseminated because of their inflated capsules (Thorne, 1965) (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Number of Populations:

111 (USFWS, 2019)

Population Narrative:

In conducting this 5-year review, best available data indicated 111 populations rangewide. Sixty-five percent (72 populations) are located on a minimum of 30 conservation lands. Destruction, modification or curtailment of its habitat or range is a likely threat to 35% of known populations because 35% of the populations exist on non-protected private land. Because 65% of the populations exist on public lands that are protected from habitat destruction, habitat destruction is not a likely current or future threat to those populations. These populations exist in eight counties. The number of individuals has been periodically assessed for the majority of the populations on conservation lands and demographic monitoring has been conducted at several of the sites. (USFWS, 2019)

Threats and Stressors

Stressor: Fire suppression (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: The most pervasive threat to *N. brittoniana* on public land is habitat degradation due to fire suppression resulting in the lack of flowering needed for reproduction. Most land managing agencies in Florida are not able to use prescribed fire at the rates, frequency, and/or intensity needed to restore and maintain most of Florida's fire-adapted ecosystems (Service 2006). Consequently, the difficulties land managing agencies currently face in implementing prescribed fires probably have resulted in the degradation of *N. brittoniana* habitat in some areas. *Nolina brittoniana* on private lands is also threatened long-term with fire suppression, but habitat destruction is a more immediate concern in many locations. Except for several privately owned conservation parcels, most other private landowners are unlikely to use habitat management techniques such as prescribed fire to maintain or enhance *N. brittoniana* habitat. At present, there are no incentives available that would encourage private landowners to undertake prescribed fire, especially those who own relatively small parcels embedded in urban matrices. As a result, we believe that many locality records for *N. brittoniana* on non-conservation parcels in private ownership are threatened with habitat modification due to fire suppression (USFWS, 2010).

Stressor: Development (USFWS, 2015)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: *Nolina brittoniana* that occur on non-conservation private lands also are vulnerable to destruction due to development, such as construction of roads; installation of utilities and other infrastructure; and residential, commercial, and industrial construction. *N. brittoniana* on each private parcel is vulnerable to this threat at any time (USFWS, 2010).

Stressor: Predation (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of individual plants

Narrative: Although more research is needed regarding predation on *N. brittoniana*, Weekley (1997) reported vertebrate predation rates over 30 percent in one population for one year on the Lake Wales Ridge State Forest. Post-dispersal fruit/seed predation might help explain the absence of seedling recruitment (Service 1999; C. Weekley, ABS, personal communication 2010). More information is needed to determine if the threat of vertebrate predation on this species has increased beyond what has naturally occurred and is causing a decline in the populations (USFWS, 2010).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: On private properties, Federal or State laws provide little protection for *N. brittoniana*. Since the majority of extant *N. brittoniana* populations occur on unprotected private lands, we conclude that existing regulatory mechanisms are inadequate to protect this species (USFWS, 2010).

Stressor: Lack of recruitment (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of genetic diversity

Narrative: There are no records of seedling recruitment in any wild population even though genetic assessments indicate seedling recruitment must take place (Menges et al. 2010). Limited seedling recruitment will affect the long-term persistence of some populations and could affect the extent of genetic variation should habitat fragmentation continue (USFWS, 2010).

Stressor: Disease (USFWS, 2019)

Exposure:

Response:

Consequence:

Narrative:

Recovery

Reclassification Criteria:

3. Within the protected populations demographic monitoring is completed for five or more sites and must be located in Highlands, Polk, Orange/Osceola and Lake Counties (USFWS, 1996).

1. Eight populations protected at four or more sites (USFWS, 1996).

2. Genetic monitoring determines the number of individuals within protected sites (USFWS, 1996).

Delisting Criteria:

For delisting, 20 viable populations at five or more sites, with sites in each of Highlands, Polk, Orange/Osceola, and Lake counties (USFWS, 1996).

Recovery Actions:

- Protect habitats of the plants. Maintain an inventory of sites and species, conduct surveys, continue land acquisition following plans adopted by governments and private conservations organizations, and pursue non-acquisition land conservation measures (USFWS, 1996).
- Manage protected habitat. Develop model fire management plans, initial inventory for each protected site, conduct initial conservation measures at each protected site, establish management objectives for each site, provide management services for each site, and monitor each site (USFWS, 1996).
- Ensure that recovery objectives are appropriate; plan for post-recovery monitoring (USFWS, 1996)
- Enforce available protective legislation. Initiate Section 7 consultation when applicable. Enforce take and trade prohibitions (USFWS, 1996).
- Provide public information about scrub and its unique biota (USFWS, 1996).
- Revise the recovery criteria to establish measurable goals for demographic monitoring, including but not limited to: the number of populations that should be monitored, the demographic parameters that should be measured, the demographic performance levels/rates that should be met, and the timeframe within which these levels/rates should be attained/maintained. Population viability analysis (modeling) should be conducted to assess the long-term persistence probability of populations (USFWS, 2010).
- Continue demographic monitoring on the Lake Wales Ridge and initiate demographic monitoring at other conservation lands where this species occurs. Conduct Level 2 (see Menges and Gordon 1996) monitoring on multiple sites using populations in different habitats and with different management regimes. Work with ABS on their Population Dynamics of Endangered Plants project which is conducting Level 2 monitoring at several sites across the range of *N. brittoniana* (USFWS, 2010).
- Conduct a range wide survey of genetic diversity in *N. brittoniana*. Such a survey could help in identifying populations that should be targeted for acquisition or included as a source for creation of new populations on sites undergoing restoration (USFWS, 2010).
- Implement management activities on public lands that contain *N. brittoniana*, including prescribed fire at return intervals and intensities necessary to restore and/or maintain the various xeric vegetative communities that support this species. Update natural community maps, which describe through field data collection (FNAI natural community mapping protocols, for example) community composition and structure along with management recommendations for managed areas where *N. brittoniana* occurs (USFWS, 2010).
- Purchase or otherwise protect large *N. brittoniana* populations on unprotected lands. Protection should target *N. brittoniana* populations that are sufficiently large, or could be large if adequately managed, as to be self-sustaining and viable long-term (USFWS, 2010).

- Encourage private landowners to conserve and manage property known to contain this species (USFWS, 2010).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Increase demographic monitoring on conservation lands. Conduct a Species Status Assessment to evaluate species viability across its current range. Review recovery criteria and revise as appropriate based on best available data. (USFWS, 2019)

References

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

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for Nineteen Central Florida Scrub and High Pineland Plants (revised). U.S. Fish and Wildlife Service, Atlanta, Georgia. 134 pp

U.S. Fish and Wildlife Service. 2010. Britton's Beargrass (*Nolina brittoniana*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jacksonville Ecological Services Field Office Jacksonville, Florida

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A." USFWS. 2019. Britton's Beargrass (*Nolina brittoniana*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region North Florida Ecological Services Office Jacksonville, Florida. 11 pp.

U.S. Fish and Wildlife Service. 2010. Britton's Beargrass (*Nolina brittoniana*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jacksonville Ecological Services Field Office Jacksonville, Florida.

USFWS. 2019. Britton's Beargrass (*Nolina brittoniana*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region North Florida Ecological Services Office Jacksonville, Florida. 11 pp.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for Nineteen Central Florida Scrub and High Pineland Plants (revised). U.S. Fish and Wildlife Service, Atlanta, Georgia. 134 pp.

U.S. Fish and Wildlife Service. 2010. Britton's Beargrass (*Nolina brittoniana*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Jacksonville Ecological Services Field Office, Jacksonville, Florida

SPECIES ACCOUNT: *Panicum niihauense* (Lau `ehu)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/10/1996; Pacific Region (R1) (USFWS, 2016)

Physical Description

A perennial grass 50-125 cm tall that grows in dense, low tufts. Stems are unbranched (NatureServe, 2015).

Taxonomy

A member of the grass family (Poaceae). This species has been maintained in the most recent treatment of Hawaiian members of the genus (Davidse 1990) (USFWS, 1999).

Historical Range

Known historically from one population each on the islands of Niihau and Kauai (USFWS, 2008).

Current Range

Currently only one population is known and it is located on the northwest corner of Kauai at Polihale State Park (USFWS, 2008).

Critical Habitat Designated

Yes; 2/27/2003.

Legal Description

On February 27, 2003, the U.S. Fish and Wildlife Service (Service), designated critical habitat pursuant to the Endangered Species Act of 1973, as amended (Act), for *Panicum niihauense* on the island of Kauai, Hawaii (68 FR 9116 - 9479).

Critical Habitat Designation

The critical habitat designation for *Panicum niihauense* includes four units totaling 428 acres in Kauai County, Hawaii. The units are Kauai 14—*Panicum niihauense*—a, Kauai 15—*Panicum niihauense*—b, Kauai 16—*Panicum niihauense*—c, and Kauai 17—*Panicum niihauense*—d.

Primary Constituent Elements/Physical or Biological Features

Within these units, the currently known primary constituent elements of critical habitat include, but are not limited to, the habitat components provided by:

(i) Sand dunes in coastal shrubland and containing one or more of the following associated native plant species: *Cassytha filiformis*, *Chamaesyce celastroides*, *Dodonaea viscosa*, *Nama sandwicensis*, *Ophioglossum pendulum* ssp. *falcatum*, *Scaevola sericea*, *Sida fallax*, *Sporobolus virginicus*, or *Vitex rotundifolia*; and

(ii) Elevations between 0 and 29 m (0 and 95 ft).

Special Management Considerations or Protections

The following management actions are important: Feral ungulate control; wildfire management; nonnative plant control; rodent control; invertebrate pest control; maintenance of genetic

material of the endangered and threatened plant species; propagation, reintroduction, and augmentation of existing populations into areas deemed essential for the recovery of the species; ongoing management of the wild, outplanted, and augmented populations; maintenance of natural pollinators and pollinating systems, when known; habitat management and restoration in areas deemed essential for the recovery of the species; monitoring of the wild, outplanted, and augmented populations; rare plant surveys; and control of human activities/access.

Life History**Food/Nutrient Resources****Lifespan**

Adult: < 10 years (USFWS, 2008)

Breeding Season

Adult: Unknown (USFWS, 1999)

Key Resources Needed for Breeding

Adult: Unknown (USFWS, 1999)

Reproduction Narrative

Adult: It is a short-lived perennial (fewer than 10 years) (USFWS, 2008). Reproductive cycles, longevity, specific environmental requirements, and limiting factors are unknown (USFWS, 1999).

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Coastal shrubland (USFWS, 1999)

Geographic or Habitat Restraints or Barriers

Adult: 30 - 50 ft. elevation (USFWS, 1999)

Habitat Narrative

Adult: Inhabits dry coastal habitats, on calcareous sand dunes and rocky knolls (NatureServe, 2015). Individuals of the single population are found scattered in sand dunes in a coastal shrubland at between 9 and 15 meters (30 and 50 feet) elevation (USFWS, 1999).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Declining

Number of Populations:

1 (USFWS, 2022)

Population Size:

3 (USFWS, 2022)

Population Narrative:

There are approximately 35 mature individuals in the wild (USFWS, 2008). At the time of the last 5-year review in 2008 there were two populations totaling 30 to 35 individuals on Kauai. The plants on Niihau were last observed in 1949. In 2006, there were 29 to 34 individuals at Polihale, 19 of which were close to Queen's Pond. In 2014, the population totaled between 4 and 11 individuals (NTBG 2014a; PEPP 2015). Watson and Nyberg (2015) reported one population of six individuals at Polihale. • Numbers of individuals observed, especially seedlings, vary with rainfall events (PEPP 2011). In 2011, over 100 seedlings were observed after heavy rains, but were gone by the next years' observations (PEPP 2012) (USFWS, 2017). Currently, there are three wild individuals of *Panicum niihauense* on Kaua'i. Seed collections and propagation are ongoing with all founders represented. One reintroduced population is within an enclosure; another is in a managed area, and both have some nonnative invasive plant control. Reintroduction is ongoing at three sites with a fourth site as a living collection (USFWS, 2022).

Threats and Stressors

Stressor: Habitat degradation (USFWS, 2008)

Exposure:

Response:

Consequence:

Narrative: The species is impacted by off-road vehicles that modify habitat and most likely destroy individual plants and introduced plant species that modify the dune habitat of and compete with *Panicum niihauense*. These invasive plant species include *Chloris barbata* (swollen fingergrass), *Leucaena leucocephala* (haole koa), *Prosopis pallida* (kiawe), *Atriplex semicoccata* (Australian saltbush), and *Verbesina encelioides* (golden crown-beard) (Tangalin 2006; Perlman 2006; USFWS 1999) (USFWS, 2008).

Stressor: Stochastic events (USFWS, 2008)

Exposure:

Response:

Consequence:

Narrative: The species is also more vulnerable to extinction due to stochastic factors, as it is currently restricted to single population (USFWS, 2008).

Stressor: Climate change loss or degradation of habitat

Exposure:

Response:

Consequence:

Narrative: Climate change may pose a threat to this species. Fortini et al. (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawaii using

high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. The assessment by Fortini et al. (2013) concluded that *Panicum niihauense* is highly vulnerable to the impacts of climate change, with a vulnerability score of 0.917 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). In addition, this species has no overlap between current and future climate envelopes, and is unlikely to tolerate expected changes in climate at its current location. This means that this species must persist within suitable microrefugia, or move to newly available climate-compatible areas to avoid extinction. Therefore, additional management actions are needed to conserve this taxon into the future (USFWS, 2017).

Stressor: Hurricanes—Loss and degradation of habitat

Exposure:

Response:

Consequence:

Narrative: Hurricanes were omitted in the last five year review. In November 1982, Hurricane Iwa struck the Hawaiian Islands, with wind gusts exceeding 100 miles per hour (mph) (161 kilometers per hour (kph)), causing extensive damage, especially on the islands of Niihau, Kauai, and Oahu (Businger 1998). In September 1992, Hurricane Iniki, a category 4 hurricane with maximum sustained wind speeds recorded at 140 mph (225 kph), passed directly over the island of Kauai. Many forest trees were destroyed (Perlman 1992), which opened the canopy and facilitated the invasion of nonnative plants (Kitayama and Mueller-Dombois 1995). A destructive hurricane holds the potential of driving a localized endemic species to extinction in a single event, and 70 percent of all listed plant species on Kauai are only found on Kauai. Hurricanes pose an ongoing and ever-present threat because they can happen at any time, although their occurrence is not predictable. Tropical cyclone frequency and intensity are projected to change as a result of climate change over the next 100 to 200 years (Vecchi and Soden 2007; Emanuel et al. 2008; Yu et al. 2010). In the central Pacific, modeling projects an increase of up to two additional tropical cyclones per year in the main Hawaiian Islands by 2100 (Murakami et al. 2013) (USFWS, 2017).

Recovery

Reclassification Criteria:

1. A total of five to seven populations should be documented on islands where it now occurs or occurred historically (USFWS, 1999).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure with the following minimum numbers of mature individuals per population: 300 for short-lived perennials (USFWS, 1999).
3. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered (USFWS, 1999).

Recovery Priority Number: 2

Delisting Criteria:

1. A total of 8 to 10 populations should be documented on islands where it now occurs or occurred historically (USFWS, 1999).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with the following minimum numbers of mature individuals per population: 300 for short-lived perennials (USFWS, 1999).
3. Each population should persist at this level for a minimum of five consecutive years (USFWS, 1999).

Recovery Actions:

- Protect habitat and control threats (USFWS, 1999).
- Expand existing wild populations (USFWS, 1999).
- Conduct essential research (USFWS, 1999).
- Develop and maintain monitoring plans (USFWS, 1999).
- Reestablish wild populations within the historic range (USFWS, 1999).
- Validate and revise recovery criteria (USFWS, 1999).
- Construct enclosure to protect population against off-road vehicular traffic (USFWS, 1999).
- Control alien plants (USFWS, 1999).
- Maintain adequate genetic stock (USFWS, 1999).
- Enhance wild population and establish new populations (USFWS, 1999).
- Conduct surveys (USFWS, 1999).
- New Management Actions:
 - Captive propagation for genetic storage and reintroduction—
 - o NTBG stores nineteen different collections of *Panicum niihauense* from Polihale in their seed bank, but it is uncertain how many founders are represented. There are also several plants in the gardens and nursery (NTBG 2017). Lyon Arboretum propagated individuals and returned them to Kauai for outplanting (PEPP 2011). PEPP has collected seeds for NTBG and Lyon Arboretum (PEPP 2010, 2011, 2014, 2015). There are ten founders from Polihale represented at the Lyon Arboretum seed bank (Lyon Arboretum 2017).
 - o Three individuals were outplanted within a fenced enclosure at Nualolo Kai (PEPP 2013). An additional 11 individuals were outplanted in 2014 (PEPP 2014). Over 300 plants have been planted at Lawai Kai (PEPP 2017).
 - o Navy Region Hawaii's 2010 INRMP provides management actions and goals for protecting *Panicum niihauense* habitat within the Pacific Missile Range Facility (PMRF) (Helber Hastert & Fee Planners, Inc. 2010). The Navy monitors the area and has restrictions on use, directing personnel to avoid sensitive dune vegetation. Planned projects (depending on funding) include invasive plant control and removal (*Prosopis pallida* (long-thorned kiawe), *Pennisetum ciliare* (syn. *Cenchrus ciliaris*; buffelgrass) and *Leucana leucocephala* (koa haole). PMRF is in the planning stages of establishing a plant nursery to propagate native plants for landscaping and habitat restoration (USFWS, 2017).
- Recommendations for Future Actions: No new threats and no other significant new information regarding the species' biological status have been reported since the last 5-year review in 2008. Therefore, the following recommendations for future actions are reiterated for the 5-year review for 2017.
 - Surveys and inventories—Survey for populations of *Panicum niihauense* in areas of potentially suitable habitat.
 - Invasive plant monitoring and control—
 - o Control established ecosystem-altering nonnative invasive plant species around all populations.
 - o Control invasive nonnative species that compete with the species around all populations.
 - Captive propagation for genetic storage and reintroduction—Continue

- propagation efforts for maintenance of genetic stock. • Reintroduction and translocation—Continue to reintroduce individuals into suitable habitat within historic range that is being managed for known threats to this species. • Human interaction monitoring and management—Develop and implement effective measures to reduce the impacts of off-road vehicles. • Stochastic events—Build resilience and redundancy—Increase numbers of populations and individuals scattered through historic range to reduce impacts from hurricanes and tsunamis (USFWS, 2017).
- Protect the species from vehicular traffic (USFWS, 2008).
 - Control introduced invasive plant species (USFWS, 2008).
 - Reintroduce the species to additional protected sites within historical range (USFWS, 2008).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: No new threats and no significant new information regarding the species' biological status have been reported since the last 5-year review in 2017. Thus, the following recommendations for future actions are reiterated or updated for the 5-year review for 2022. • Surveys and inventories—Continue to survey for populations of *Panicum niihauense* in areas of potentially suitable habitat. • Nonnative invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species and those that compete with *P. niihauense* at all populations. • Climate change adaptation strategy—Research suitability of habitat for viability of species, including where to conduct translocations in the future due to impacts of climate change. • Captive propagation for genetic storage and reintroduction—Continue collection and propagation efforts for maintenance of genetic stock. • Reintroduction and augmentation—Continue to reintroduce individuals and augment populations into protected suitable habitat within historic range that is being managed for known threats to this species. • Build resiliency and redundancy—Increase numbers of individuals and populations through habitat restoration and translocation in suitable habitat where threats are controlled to reduce impacts of climate change, including hurricanes, as well as small population size. • Human interaction monitoring and management—Continue to implement measures to prevent disturbance and destruction by use of off-road vehicles. • Alliance and partnership development—Continue to work with partners and other land managers in planning and implementation of ecosystem-level restoration and management to benefit this species (USFWS, 2022).

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

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

USFWS 2008. *Panicum niihauense* (Lau 'ehu) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

U.S. Fish and Wildlife Service. 1999. Recovery Plan for Multi-Island Plants. U.S. Fish and Wildlife Service, Portland, OR. 206 pages + appendices.

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants

Final Designation or Nondesignation of Critical Habitat for 95 Plant Species From the Islands of Kauai and Niihau, HI. Final rule. 68 FR 9116 - 9479 (February 27, 2003).

USFWS 2008. *Panicum niihauense* (Lau 'ehu) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii

USFWS 2008. *Panicum niihauense* (Lau 'ehu) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. U.S. Fish and Wildlife Service. 2017. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Panicum niihauense* (Lau'ehu). USFWS. 2022. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Panicum niihauense* (lau'ehu). Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii. 9 pages.

USFWS. 2008. *Panicum niihauense* (Lau 'ehu) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2017. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Panicum niihauense* (Lau'ehu).

USFWS 2008. *Panicum niihauense* (Lau 'ehu) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii.

USFWS. 2022. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Panicum niihauense* (lau'ehu). Region 1/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii. 9 pages.

SPECIES ACCOUNT: *Piperia yadonii* (Yadon's piperia)

Species Taxonomic and Listing Information

Listing Status: Endangered; Pacific Southwest (R8) (USFWS, 2015)

Physical Description

A perennial herb with only 1-2 basal leaves, dying back each winter, visible above ground for the first few years of its growth. After several years, the plant produces a single flowering stem, up to 8 dm tall, with white and green flowers arranged in a narrow, dense cluster, generally 5-15 cm long. Blooms in summer. (NatureServe, 2015). *Piperia yadonii* (Yadon's piperia) is a slender perennial herb in the orchid family (Orchidaceae). (USFWS, 2019)

Taxonomy

Piperia yadonii (Figure 5) was first collected by Leroy Abrams in 1925 in open pine forest near Pacific Grove. It was originally identified as a polymorphic (having or occurring in several distinct forms), wide-ranging species in the western United States known as *Piperia unalascensis* (Morgan and Ackerman 1990). At least two naturalists (i.e., George Henry Grinnel and Leroy Abrams) who collected from the Monterey region in the 1920's noted the uniqueness of the plants from this locality (Coleman 1995). In the most recent treatment of the genus *Piperia*, Ackerman (1977) segregated out several long-spurred taxa from the *P. unalascensis* complex but attempted no analysis of the short-spurred forms (which would eventually include *P. yadonii*). Subsequently, Morgan and Ackerman (1990) segregated out two new taxa from the *P. unalascensis* complex on the basis of floral markings, inflorescence type, and partly on geographic range. One of these taxa (i.e., *Piperia yadonii*) was named after Vernal Yadon, Director Emeritus of the Museum of Natural History in Pacific Grove, Monterey County (USFWS, 2004).

Historical Range

Since preparation of the listing rule, *Piperia yadonii* has been found at one location about 15.5 miles (mi) (25 kilometers (km)) south of the Monterey Peninsula near Palo Colorado Canyon in maritime chaparral (Norman, in litt. 1995). Maritime chaparral is uncommon along this region of the Big Sur coastline, but a few scattered patches do occur south to Pfeiffer Point, located about 25 mi (40 km) from the Peninsula (Norman, pers. comm. 1997). *Piperia yadonii* has been found only 4 to 6 mi (6 to 10 km) inland (Allen 1996; Yadon, in litt. 1997) despite searches of lands farther east (Allen 1996). (USFWS, 2009)

Current Range

Occurs in three distinct groups of sites. It is endemic to Monterey Co., California. (NatureServe, 2015)

Critical Habitat Designated

Yes; 10/24/2007.

Legal Description

On October 24, 2007, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Piperia yadonii* (Yadon's piperia) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes eight critical habitat units (CHUs), in California (72 FR

60410-60450).

Critical Habitat Designation

The critical habitat designation for *Piperia yadonii* includes eight CHUs (including 18 sub-units) in Monterey County, California. This species critical habitat encompasses approximately 2,117 acres (ac) (857 hectares (ha)) (72 FR 60410-60450).

Unit 1: Blohm Ranch: Unit 1 consists of 128 ac (52 ha) of private lands in northern Monterey County in the Elkhorn Slough watershed. It is divided into two ridgeline subunits, separated by intervening agricultural fields. The two subunits support similar plant communities and need similar types of special management considerations or protection; therefore, we discuss them as a unit, except to define land ownership or acreage. Unit 1 was occupied at the time of listing (Service 1998) and is currently occupied. It supports one of the two largest occurrences of *Piperia yadonii* plants in the Prunedale Elkhorn area (several thousand plants (Allen 1996 unpaginated)) and the northernmost occurrences in the known range of the species. This unit contains features that are essential for the conservation of *P. yadonii*, including soils from weathered marine sediments that are classified as an Arnold Santa Ynez complex on the ridgetops and as Arnold series soils on the slopes (PCE 1). Vegetation is primarily high quality maritime chaparral, with ridgetops dominated by low-growing Hooker's manzanita. This unit provides habitat that supports germination, growth, and reproduction of *P. yadonii*. It contains ridgetop habitat openings, between and among patches of *P. yadonii*, to allow for population expansion and for shifts in population location, should successional vegetation or other changes occur that alter microhabitat conditions. Features essential to the conservation of *P. yadonii* in this unit may require special management considerations or protection due to: the growth and spread of invasive plant species (such as jubata grass); erosion from old roadbeds or past earth-moving activities; and herbivory (PCE 1, PCE 2). Herbivory of flowering stalks was 36 percent in 1999, although predators (mountain lion (*Puma concolor*)) of herbivores were recently sighted on these lands (Doak and Graff 2001, p. 28; Graff 2006, Appendix IV). Given that pollen deposition rates and seed production were low for the one site studied in this unit, special management may also be needed to ensure that the abundance of potential pollinators, such as moths or bees, are maintained or enhanced (PCE 2). **Subunit 1a:** This subunit consists of 72 ac (29 ha) of private land owned by the Elkhorn Slough Foundation and The Nature Conservancy. Although restoration and removal of nonnative invasive plant populations are ongoing, a management plan specifically addressing *Piperia yadonii* on properties owned by the Elkhorn Slough Foundation and The Nature Conservancy has not yet been developed (Hayes 2006). **Subunit 1b:** This subunit consists of 56 ac (23 ha) of land owned by The Nature Conservancy and managed by the Elkhorn Slough Foundation, or owned and managed by the Elkhorn Slough Foundation. A management plan specifically addressing *Piperia yadonii* has not yet been developed.

Unit 2: Manzanita Park: Unit 2 consists of 498 ac (201 ha) of Monterey County lands north of Prunedale. It is divided into 3 subunits that support similar soils and vegetation communities and need similar types of special management considerations or protection; therefore, we discuss these characteristics for the whole unit. Unit 2 was occupied at the time of listing (Service 1998) and is currently occupied. The lands in this unit support several thousand *Piperia yadonii* plants scattered along the ridges, separated by intervening lower-elevation areas of oak woodland, farmed lands, and residential development (Allen 1996 unpaginated; Environmental Science Associates 2003; CNDDDB 2005; Graff 2006 appendix IV). This unit contains features that are essential for the conservation of *P. yadonii*, including soils from weathered marine sediments

that are classified as an Arnold–Santa Ynez complex on the ridgetops and as Arnold series soils on the slopes and on more undulating topography within Manzanita County Park (PCE 1). Vegetation within the subunits is primarily maritime chaparral, with some coast live oak woodland at the lower elevations. The ridgetops are dominated by low-growing Hooker's manzanita. This unit contains the PCEs for *P. yadonii* that promote germination, growth, and reproduction (PCE 1). This unit encompasses a cluster of three ridgelines primarily oriented east-west that rise in elevation from west to east, which support *P. yadonii* and which may be close enough for genetic exchange via wind-dispersed seed. In conjunction with the Blohm Ranch unit (Unit 1), this unit encompasses the majority of the *P. yadonii* plants known in the northern half of the range of *P. yadonii*. The ridgetop habitat openings, between and among patches of *P. yadonii*, allow for population expansion and for shifts in population location, should successional vegetation or other changes occur that alter microhabitat conditions. This unit is the central of the three in the Elkhorn Prunedale geographic area. This unit supports one of the two largest occurrences in the species' northern range, and the subunits of Unit 2 include the largest occupied ridgelines relatively unfragmented by residential development in the heart of the species' northern distribution. Due to their relatively unfragmented condition, lands in this unit may support dormant plants among the patches of currently known *P. yadonii*. Features in this unit may require special management considerations or protection due to: the growth and spread of invasive plant species, such as jubata grass, French broom, and eucalyptus; elimination or further fragmentation of habitat from residential, recreational, or agricultural development; vegetation removal for fuel reduction purposes; disease; and herbivory (PCE 1, PCE 2). Habitat with features essential to the conservation of *P. yadonii* in this unit may require special management considerations or protection to ensure the abundance of potential pollinators, such as moths or bees, are maintained or enhanced, to ensure the production of sufficient viable seed (PCE 2). Subunit 2a: This subunit consists of 231 ac (93 ha) of land owned and managed by the Elkhorn Slough Foundation. Subunit 2b: This subunit consists of 83 ac (34 ha) of private lands. Some of the lands in this subunit were proposed for a 10-lot subdivision, residential development, and open space designation in 2000 (Mercurio 2000, p. 2); this project may be moving forward in the near future (Schubert 2006). Subunit 2c: This subunit consists of 183 ac (74 ha) within Manzanita County Park, owned and managed by the County of Monterey. Part of the park has been developed into a sports complex and is not part of the designation. A portion of the park within the unit is used for hiking and equestrian use. Although volunteers have recently begun removing nonnative invasive plants from the park, we are not aware of the existence of any management plan that specifically addresses *Piperia yadonii* on properties owned by Monterey County.

Unit 3: Vierra Canyon: Unit 3 consists of 50 ac (20 ha) consisting primarily of State lands in northern Monterey County north of Prunedale. It is divided into 3 subunits with similarities in vegetation and special management considerations or protection needs. Unit 3 was occupied at the time of listing (Service 1998) and is currently occupied (Childs 2004). The easternmost *Piperia yadonii* occurrences in unit 3 (subunits 3b and 3c) are reported to be small, with fewer than 10 flowering individuals; this likely represents up to several hundred individuals, based on the observed proportion of flowering to vegetative individuals (Doak and Graff 2001). This unit contains features that are essential for the conservation of *P. yadonii*, including the following: Lands in this unit support soils from weathered marine sediments that are classified as an Arnold–Santa Ynez complex on the ridgetops and the Arnold series on the slopes (PCE 1). Vegetation is primarily maritime chaparral, with coast live oak woodland in the lower elevation areas. The ridgetops are dominated by lowgrowing Hooker's manzanita. Analysis of aerial photographs suggests that chaparral vegetation on the ridgetops in this region maintains a more open canopy

than in areas to the west, in the areas of Units 1 and 2 (Van Dyke 2006). Therefore, these areas may support openings that are more persistent, and can be occupied by *P. yadonii* for a longer time, than areas to the west, even in the absence of fire (Van Dyke 2006). The lands surrounding these subunits are more extensively developed for residential use than are those to the west, severing the once continuous maritime chaparral that dominated the ridges. Consequently the subunits are smaller and lack the additional habitat for population expansion found in the other northern units. This unit contains the PCEs for *P. yadonii* that promote germination, growth, and reproduction. It supports the easternmost occurrences of *P. yadonii* in the Elkhorn'Prunedale region, on the northeast periphery of the species' range. Features essential to the conservation of *P. yadonii* in this unit may require special management considerations or protection due to elimination or further fragmentation of habitat from development, grading or other vegetation removal (e.g., for fuel reduction purposes or roads), and the spread of invasive plant species (PCE 1, PCE 2). Subunit 3a: This subunit consists of 17 ac (7 ha) of private lands that are overlain by a Pacific Gas and Electric Company easement. The occurrence in this subunit is the largest documented in Unit 3, numbering several thousand plants (Childs 2004). Subunit 3b: This subunit consists of 12 ac (5 ha) of State lands (California Department of Transportation (Caltrans)). The lands in this subunit and in subunit 3c were part of a previous study area for a highway alignment. This alignment was eventually excluded from further consideration and the State retains the lands (Robison 2006). We are not aware of any management plan that addresses *Piperia yadonii* on these State properties. Subunit 3c: This subunit consists of 21 ac (8 ha) of State lands, owned by Caltrans.

Unit 4: Aguajito: Unit 4 consists of 108 ac (44 ha) of private land east of the Monterey Peninsula and north of Jack's Peak County Park. It is divided into 2 subunits separated by lower elevation lands. Unit 4 was occupied at the time of listing (Service 1998) and is currently occupied. *Piperia yadonii* occurs in these subunits on ridgetops, where it grows with Hooker's manzanita (EcoSystems West 2006, p. 61). This unit contains features that are essential for the conservation of *P. yadonii*, including the following: Soils in this unit are classified as the Santa LuciaReliz Association, where Reliz series soils occur on the ridgetops and Santa Lucia series soils on surrounding slopes (PCE 1). Reliz series soils are characterized as excessively drained shaley clay loams underlain by shale or sandstone (USDA 1978, p. 64). The vegetation in the unit is a mix of Monterey pine forest and maritime chaparral. Griffin (1978, p. 69) commented that this area was one of the only ones in the Monterey Bay area where maritime chaparral grows on shale. He also noted that sandstones exist within the shale beds and produce sandy loam soils. A related species, *Piperia elegans*, is more abundant in the surrounding Monterey pine forest (EcoSystems West 2005b, p. 7). This unit provides habitat that supports germination, growth, and reproduction. Unit 4 represents one of only two units in the region interior to the Monterey Peninsula. It supports the largest undeveloped easternmost occurrence of *P. yadonii* in the central and southern half of the species' range. Its preservation will help avoid range collapse. Features essential to the conservation of *P. yadonii* in this unit may require special management considerations or protection due to fragmentation of habitat from development and the colonization and spread of invasive plant species (PCE 1, PCE 2). We are also excluding 49 acres (20 ha) from this subunit as a result of the Pebble Beach Company's conservation agreement. Subunit 4a: This subunit consists of 49 ac (20 ha) of private lands (owned by the Pebble Beach Company). Lands in and/or adjacent to this subunit and subunit 4b are proposed for preservation in the Pebble Beach Company's recent development plan, but the configuration of the preservation areas is not yet determined (Monterey County 2005, pp. 2–89, 2–90). Subunit 4b: This subunit consists of 56 ac (24 ha) of private lands (owned by the Pebble Beach Company) and

proposed for preservation (see above), and 3 ac (1ha) of Monterey County road right-of-way.

Unit 5: Old Capitol: Unit 5 consists of 16 ac (7 ha) of private land (owned by the Pebble Beach Company) east of the Monterey Peninsula. Unit 5 was occupied at the time of listing (Service 1998) and is currently occupied. Surveys in 2005 revealed that the dominant *Piperia* species at this location is *P. elegans*, which number in the thousands; however, several hundred *P. yadonii* cooccur with *P. elegans* throughout the unit (EcoSystems West 2005b, pp. 5–7). This unit contains features that are essential for the conservation of *P. yadonii*, including the Chamise shaley clay loam (PCE 1) soil type. The vegetation is Monterey pine forest and coast live oak woodland. This unit provides habitat that supports germination, growth, and reproduction of *P. yadonii*. It is the only unit designated between the Monterey Peninsula (Unit 6) and Aguajito (Unit 4) to the east and, therefore, provides connectivity between these other two units. Features essential to the conservation of *P. yadonii* may require special management considerations or protection in this unit due to: Fragmentation or loss of habitat from development, habitat degradation by motorized vehicles and encampments, debris dumping, and competition from nonnative invasive plants (PCE 1, PCE 2). The land in Unit 5 is proposed for preservation in the Pebble Beach Company's recent development plan (Monterey County 2005, pp. 2–89, 2–90).

Unit 6: Monterey Peninsula: Unit 6 consists of 920 ac (372 ha) of private and City lands on the Monterey Peninsula. This unit is divided into 5 subunits due to intervening development. Most of the lands surrounding this unit are developed for residential and recreational (golf) use. The similarities among the subunits in soils and vegetation community are discussed here; subunit specific details are discussed below. Unit 6 was occupied at the time of listing (Service 1998) and is currently occupied. It supports the greatest abundance and largest aerial extent of *Piperia yadonii* in the species' range, with close to 100,000 vegetative plants (Zander Associates and WWD Corporation 2004, all pp.; EcoSystems West 2004, pp. 1–9; EcoSystems West 2005a, 2005b, all pp.). This unit contains features that are essential for the conservation of *P. yadonii* including sands or sandy loam soils that belong to at least 5 soil series on the Monterey Peninsula unit (Baywood sands, Narlon loamy fine sands, Sheridan coarse sandy loams, Tangair fine sands, and Santa Lucia shaley clay loam). Vegetation in this unit is primarily Monterey pine forest, with maritime chaparral, and Bishop pine/Gowen cypress forest in two subunits (PCE 1). Pollinator observations and collections were made on lands in this unit (PCE 2) (Doak and Graff 2001). This unit provides habitat that supports germination, growth, reproduction, and space for shifts in the location of *P. yadonii*, as microhabitat conditions change. Features essential to the conservation of *P. yadonii* may require special management in this unit due to: Adverse effects from adjacent existing and future development, including the loss of adjacent forest canopy, increased trampling, potential hydrologic changes, overspray of pesticides, the introduction of pathogens or disease, mowing, and the introduction and spread of invasive plant species; continuing high and/or increasing deer populations resulting in high herbivory levels; and increased growth of understory vegetation due to exclusion of wildfire (PCE 1, PCE 2). **Subunit 6a:** This subunit consists of 810 ac (328 ha) of private lands owned by the Pebble Beach Company and other private owners, including 17 ac (7 ha) owned by the Del Monte Forest Foundation (DMFF). Protected lands in this subunit include the SFB Morse Botanical Reserve (owned by the DMFF) and the Huckleberry Hill Natural Reserve (easement held by the DMFF). It also includes lands identified in the Pebble Beach Company's most recent development proposal for preservation or conservation: Areas PQR, G, H, I, the Corporate Yard Preservation Area, and Area D (Monterey County 2005). The Department of the Army's Presidio of Monterey is contiguous with the

northeastern edge of this subunit; those lands are exempted from this designation, as described later in this rule. We have also excluded 54 acres (22 ha) from this subunit as a result of the Pebble Beach Company's conservation agreement and 6 ac (2.4 ha) from the Stevenson School property. We have also removed 35 acres (including Area D) because they do not support the PCEs. Please see the section Relationship of Critical Habitat to Approved Management Plans—Exclusions Under Section 4(b)(2) of the Act and our responses to Comments 12 and 13, for a discussion of these exclusions. Plant communities in the Huckleberry Hill Natural Area and SFB Morse Botanical Preserve are Gowen cypress/ Bishop pine forest, maritime chaparral, and Monterey pine forest. The remaining lands support primarily Monterey pine forest. Lands in this subunit support about 90,000 vegetative *Piperia yadonii* plants (Zander Associates and WWD Corporation 2004 all pp.; EcoSystems West 2004, pp. 1–9; EcoSystems West 2005a, 2005b, all pp.). Although the DMFF conducts some monitoring and removal of nonnative invasive plant populations, a management plan specifically addressing *P. yadonii* on properties owned by the DMFF has not been developed.

Subunit 6b: This subunit consists of 6 ac (2 ha) of private lands. It is identified in the Pebble Beach Company's most recent development proposal as the Bristol Curve Conservation Area (Monterey County 2005 Fig. ES–2). This subunit is part of a larger area identified by the Pebble Beach Company as Area MNOUV, which supports about 116 ac (47 ha) of Monterey pine forest and one of the two largest known occurrences of *Piperia yadonii* (about 57,000 plants (Zander Associates and WWD Corporation 2004)). The Monterey pine forest of MNOUV outside the proposed Bristol Curve conservation area is proposed for development as a golf course (Monterey County 2005). Vegetation in this subunit is Monterey pine forest with an herbaceous understory. We are excluding 1 acre (1 ha) from this subunit as a result of the Pebble Beach Company's conservation agreement, and as a result of boundary adjustments, we have not included 2 acres of proposed critical habitat within this subunit that do not support the PCEs. Please see the section Relationship of Critical Habitat to Approved Management Plans—Exclusions Under Section 4(b)(2) of the Act and our responses to Comments 12 and 13, for a discussion of these exclusions.

Subunit 6c: This subunit consists of 31 ac (13 ha) of private lands, of which about 23 acres (9 ha) are owned by the DMFF. Lands within this unit are referred to as Indian Village (owned by the DMFF) and, in the Pebble Beach Company's recent development proposal, as Conservation Area K and Preservation Areas J and L (Monterey County 2005 Fig. ES–2). Adjacent lands (Part of Area K) that are proposed for development are not included in this subunit. We are excluding 37 acres (15 ha) from this subunit as a result of the Pebble Beach Company's conservation agreement, and we have removed 2 acres (1 ha) as a result of boundary adjustments to account for areas that do not support the PCEs. Please see the section Relationship of Critical Habitat to Approved Management Plans—Exclusions Under Section 4(b)(2) of the Act and our responses to Comments 12 and 13, for a discussion of these exclusions. The vegetation in this subunit is primarily Monterey pine forest. This subunit supports several thousand *Piperia yadonii* plants (Zander Associates and WWD Corporation 2004). Along with subunits 6b and 6d, it encompasses lands in the westernmost region of the Monterey Peninsula.

Subunit 6d: This subunit consists of 12 ac (5 ha) of private lands owned by the DMFF. It encompasses the Crocker Grove, an area of Monterey cypress forest with some adjacent Monterey pine forest (PCE 1). This is the westernmost subunit on the peninsula, closest to the ocean, and lands it occurs on are mapped as marine terrace 2 (Jones and Stokes 1994b, p. 11). It has been documented to support about 50 flowering *Piperia yadonii* plants (Van Dyke et. al. 2006), which typically equates to several hundred vegetative plants.

Subunit 6e: This subunit consists of 42 ac (17 ha) of private lands and 19 ac (7 ha) owned by the City of Pacific Grove. About 29 ac (12 ha) of the private lands are owned by the DMFF. Lands within this unit are referred to as the Navajo tract and as Preservation Area B in the Pebble Beach Company's most

recent development proposal (Monterey County 2005 Fig. ES–2). We are excluding 2 acres (1 ha) from this subunit as a result of the Pebble Beach Company’s conservation agreement. Please see the section Relationship of Critical Habitat to Approved Management Plans—Exclusions Under Section 4(b)(2) of the Act for a discussion of this exclusion. The vegetation in this subunit is a mix of coast live oak and Monterey pine forest (PCE 1). It is the northernmost unit we are designating on the Peninsula. It supports several hundred plants of *Piperia yadonii* (Zander Associates and WWD Corporation 2004).

Unit 7: Point Lobos Ranch: Unit 7 consists of 228 ac (92 ha) of State land south of the Monterey Peninsula on the Big Sur coast, and 97 ac (39 ha) owned by the Big Sur Land Trust that are intended to be added to the State Parks system in the future. Unit 7 was occupied at the time of listing (Service 1998) and is currently occupied. The lands in this unit support several thousand *Piperia yadonii* plants (Graff et al. 2003, Nedeff et al. 2003). This unit contains features that are essential for the conservation of *P. yadonii*, including the sandy loam soils in the Sheridan, Narlon, Junipero Sur complex series, underlain by granitic substrates from which terrace sands have been eroded (Griffin 1978, p. 69, USDA 1978 map no. 35). Vegetation is a composite of Monterey pine forest, maritime chaparral, Gowen cypress Bishop pine forest, with some redwood forest. *Piperia yadonii* occurs in this unit in Monterey pine forest; on exposed granitic soils in maritime chaparral dominated by Hooker’s manzanita; and under a canopy of Monterey pine, Gowen cypress, and redwood (*Sequoia sempervirens*) (PCE 1). This unit provides habitat that supports germination, growth, and reproduction of *P. yadonii*, as well as population expansion and shifts in population location. This unit supports *P. yadonii* growing on soils not found in other units and in association with a varied mix of forest tree species. This is the second highest unit in elevation and supports the largest occurrence of *P. yadonii* south of the Monterey Peninsula (Graff 2006). Features essential to the conservation of *P. yadonii* may require special management in this unit due to: the growth and spread of invasive plant species, such as French broom; loss of habitat from residential development; and erosion (PCE 1, PCE 2). Access by park visitors may need to be managed to avoid creation of trails in Monterey pine forest populations and use of herbicides should be controlled to avoid or minimize effects to *P. yadonii* (PCE 1).

Unit 8: Palo Colorado: Unit 8 consists of 73 ac (29 ha) of private land on the Big Sur coast. Unit 8 was occupied at the time of listing (Service 1998) and is currently occupied. The lands in this unit were reported to support 38 flowering *Piperia yadonii* plants (Norman 1995), which likely represents a population of several hundred to several thousand vegetative individuals, based on the observed proportions of flowering to vegetative individuals (Doak and Graff 2001). This unit contains features that are essential for the conservation of *P. yadonii* including the following: A mix of sandy loam soils, shallow soils less than 20 inches deep, and rock outcrops classified as the Junipero-Sur complex and Rock Outcrop—Xerorthents Association (PCE 1) (USDA 1978, p. 38). Vegetation in this unit has been described as a unique association of maritime chaparral, with low-growing hybrid *Arctostaphylos glandulosa* as the dominant manzanita under which *P. yadonii* occurs (Norman 1995). This unit provides habitat that supports germination, growth, and reproduction of *P. yadonii*. This unit supports the most southern and highest elevation (1,000 to 1,400 feet (300 to 430 m)) occurrence in the species’ range. Features essential to the conservation of *P. yadonii* may require special management in this unit due to habitat fragmentation and habitat degradation from road and trail grading and from future development, such as the introduction and spread of nonnative plants, removal of native vegetation, erosion, and hydrologic changes (PCE 1, PCE 2).

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 *Piperia yadonii* critical habitat consists of two components (72 FR 60410-60450):

(i) A vegetation structure providing filtered sunlight on sandy soils: (A) Coastal pine forest (primarily Monterey pine) with a canopy cover of 20 to 70 percent, and a sparse herbaceous understory on Baywood sands, Narlon loamy fine sands, Sheridan coarse sandy loams, Tangair fine sands, Santa Lucia shaly clay loams and Chamise shaley clay loams underlain by a hardpan; or (B) Maritime chaparral ridges with dwarfed shrubs (primarily Hooker's manzanita) on Reliz shaly clay loams, Sheridan sandy loams, Narlon sandy loams, Arnold loamy sands and soils in the Junipero-Sur complex, Rock Outcrop-Xerorthents Association, and Arnold-Santa Ynez complex, often underlain by rock outcroppings.

(ii) Presence of nocturnal, shorttongued moths in the families Pyralidae, Geometridae, Noctuidae, and Pterophoridae.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the occupied areas contain the features essential to the conservation of the species that may require special management considerations or protection. Many of the known occurrences of *Piperia yadonii* are threatened by one or a combination of the following: habitat fragmentation or loss due to residential, commercial, or recreational development; competition with nonnative plants for light, space, or water; deer and rabbit herbivory; vegetation cutting for fire prevention; changes in light, space, and soil moisture availability due to loss or alteration of adjacent vegetation or forest canopy; changes in fecundity (number and viability of offspring) or genetic variability resulting from loss and fragmentation of populations or potentially low pollinator abundance or activity; disease; and trampling (PCE 1, PCE 2). In maritime chaparral associations of the Prunedale-Elkhorn region where fire has not occurred in many decades, shrub diversity appears to be declining as coast live oak or large-canopied manzanitas become dominant (Van Dyke et al. 2001, pp. 225–227). This conversion may be slow in the shallow ridgetop soils where *P. yadonii* occurs, but increasing development surrounding these ridgetops reduces the opportunity to use fire as a management tool should it be deemed necessary to maintain the open, low-canopy conditions of *P. yadonii*'s preferred habitat (PCE 1). These threats may require special management and are addressed under the critical habitat unit descriptions below.

Life History**Food/Nutrient Resources****Reproduction Narrative**

Adult: As in other orchids, germination of *P. yadonii* seeds probably involves a symbiotic relationship with a fungus. Following germination, orchid seedlings typically grow below ground for 1 to several years before producing their first basal leaves. Plants may produce only vegetative growth for several years, before first producing flowers (Rasmussen 1995). In mature plants of *P. yadonii*, the basal leaves typically emerge sometime after fall or winter rains and wither by May or June, when the plant produces a single flowering stem. Consistent with what is known of other orchid species, Allen (1996) observed that only a small percentage of the *Piperia*

yadonii plants in a population may flower in any year. Individual orchids that flower in one year may not have the necessary energy reserves to flower in the following year, so size and flowering are not necessarily age-dependent (Wells 1981, Rasmussen 1995). Although *Piperia yadonii* is capable of self-pollination, the rate of production of viable seeds is higher in plants pollinated by insects (Doak and Graff 2001). Doak and Graff (2001) found that pollinators of *Piperia yadonii* are predominantly nocturnal, short-tongued moths. In order to maintain adequate seed production to support long-term persistence of the species, suitable habitat of sufficient size and connectivity for these pollinators also needs to be maintained (USFWS, 2009). *Yadon's Rein orchid* is a later successional species, taking up to 15 years after habitat disturbance before colonizing or re-colonize a site (Allen 1996). It's ability to sustain and re-colonize after habitat disturbance is dependent upon changes to the habitat, mostly due to edge effects (United States Fish and Wildlife Service 2009). Mycorrhizal fungal associations do not seem to limit colonization or it's range because it associates with a number of fungal families (Pandey et al. 2013) (NatureServe, 2015).

Habitat Type

Adult: Forest/chaparral (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Habitat Narrative

Adult: Species inhabits monterey pine forest and maritime chaparral communities, primarily on poorly drained sandstone and sandy soils. (NatureServe, 2015)

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Decreasing (NatureServe, 2015)

Number of Populations:

21 - 80 (NatureServe, 2015)

Population Size:

10,000 - 100,000 individuals (NatureServe, 2015)

Additional Population-level Information:

The blooming season is brief, usually starting in mid-June and ending in early August (Coleman 1995, Doak and Graff 2001) (USFWS, 2009).

Population Narrative:

As observed with other orchids, germination of seeds is believed to involve a symbiotic relationship with a fungus. The blooming season is brief, usually starting in mid-June and ending in early August (Coleman 1995, Doak and Graff 2001). Individuals that flower in one year may not flower the next, and a portion of the population may be completely dormant in any given year (USFWS, 2009). This localized endemic is an orchid which is not always visible throughout

its life cycle. It is therefore highly vulnerable. Long term trend is assumed to have been sharply downwards due to the high rate of development over the past 200 yrs in the plant's habitat. Decline of 30-50% About 47000 plants known from 28 sites (CNDDDB 2014). One site contains about 80% or 39000 plants. 29 known EO's; 1 is extirpated (CNDDDB 2014) (NatureServe, 2015). Moderate resiliency, representation and redundancy are based on the number of known populations and individuals.

Threats and Stressors

Stressor: Development (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Urban and recreational developments, specifically golf courses on the Monterey Peninsula, continue to threaten this plant's existence. Golf course development is less of a threat than at the time of listing due to the Coastal Commission's denial of Pebble Beach Company's plans for development of a new golf course on the area containing the largest population of *Piperia yadonii* within the range of the species in 2007 (USFWS, 2009).

Stressor: Predation (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Although the Service is not aware of any quantitative data on mule deer populations on the Monterey Peninsula, anecdotal evidence, such as sightings and reports of health, suggest that the number of deer on the Peninsula is high (Matthews, California Native Plant Society, in litt. 1996; Steeck, USFWS, pers. obs. 1996). If the loss of 85 percent of flowering stems calculated by Allen (1996) is close to actual herbivory rates on the Monterey Peninsula, predation could continue to have a substantial effect on the reproductive success of the species, particularly if populations are reduced by large-scale habitat loss and fragmentation due to development. Graff (2006) suspected that populations of *Piperia yadonii* occurring in forests surrounded by large areas of high-quality habitat may have herbivory rates above 70 percent compared to around 40 percent in populations in chaparral. High rates of herbivory could severely impact *Piperia yadonii* populations by reducing individual plant survivorship as well as reproduction (EcoSystems West 2008) (USFWS, 2009).

Stressor: Inadequacy of Existing Regulatory Mechanisms (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: At the time of listing, regulatory mechanisms thought to have some potential to protect *Piperia yadonii* included: the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), and the Act in those cases where *Piperia yadonii* occurs and is incidentally protected in habitat occupied by a listed wildlife species. The listing rule (74 FR 12878) provides an analysis of the level of protection that was anticipated from those regulatory mechanisms. This analysis appears to remain valid. The Act is the primary Federal law that provides protection for this species since its listing as endangered in 1998. The California Coastal Commission, in cooperation with Monterey County, conducts periodic reviews of the

implementation and effectiveness of Monterey County's Local Coastal Program in carrying out the goals and policies of the California Coastal Act. Corrective actions or recommendations are provided by the Commission to the County and will be integrated into Monterey County's 21st Century General Plan Update. Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Act (USFWS, 2009).

Stressor: Stochastic extinction (USFWS, 2009)

Exposure:

Response:

Consequence: Extinction

Narrative: At the time of listing, *Piperia yadonii* was threatened with extinction from natural random acts by virtue of the limited number of individuals and range of the existing populations. Small populations are also vulnerable to extinction by a single human-caused or natural event. Inbreeding may affect small or isolated populations if it results in inbreeding depression. Since the time of listing, the known range of the species and number of individuals and populations has increased as a result of extensive survey efforts. Our current assessment is that the risk of stochastic extinction is less than at the time of listing due to the increase in the size of several of the populations. However, other populations continue to be at risk due to their small size and isolation from surrounding suitable habitat (USFWS, 2009).

Stressor: Competition with non-native species (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: The *Piperia yadonii* listing rule states that *Cortaderia jubata* (pampas grass) and *Genista monspessulana* (French broom) are two non-native plant taxa that invade forests and meadows on the Monterey Peninsula. In addition, *Acacia* spp. (acacia) and *Briza maxima* (rattlesnake grass) have been listed as threats in the Del Monte Forest populations (Ecosystems West 2008). The Pebble Beach Company has an on-going eradication program for these taxa (Pebble Beach Co. 2008). Due to aspects of the life history of *Piperia yadonii*, such as dormancy, more monitoring will be necessary to determine the response of the species after non-native species removal (Ecosystems West 2008). Invasion of non-native plants is a continuing threat and could increase in severity if the remaining populations are reduced in size, dissected into many smaller parcels, or become isolated by surrounding development (USFWS, 2009).

Stressor: Fire prevention and fire suppression activities (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: At the time of listing, maintenance of firebreak roads in Monterey pine forest was described as providing open habitat for invasive, non-native species. It was believed that these species could never be eradicated from the area due to the necessity of maintaining the firebreak roads. Clearing and maintaining exposed ground that could allow the establishment or persistence of non-native species continues to pose a threat to *Piperia yadonii*. Fire suppression activities could pose a threat to *Piperia yadonii*. Periodic fire could remove dense vegetation and

reduce organic accumulation on the ground to provide better habitat for *Piperia yadonii* (USFWS, 2009).

Stressor: Climate change (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field et al. 1999, Cayan et al. 2005, IPCC 2007). Recently, the potential impacts of climate change on the flora of California were discussed by Loarie et al. (2008). Based on modeling, they predicted that species' distributions will shift in response to climate change, specifically that the species will "move" or disperse to higher elevations and northward, depending on the ability of each species to do so. Species diversity will also shift in response to these changes with a general trend of diversity increases shifting towards the coast and northwards with these areas becoming de facto future refugia. Coastal populations will be particularly vulnerable to habitat loss and degradation due to sea level rise and storm surges. However, predictions of climatic conditions for smaller sub-regions such as California remain uncertain. It is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects. While we recognize that climate change is an important issue with potential effects to listed species and their habitats, we lack adequate information to make accurate predictions regarding its effects to *Piperia yadonii* at this time (USFWS, 2009).

Recovery

Reclassification Criteria:

Secure and protect areas throughout the present range of *Piperia yadonii* that contain populations of sufficient size to ensure the long-term survival and recovery of the species (USFWS, 2009).

Protected areas are adequately maintained, such that encroachment by non-native plants, excessive herbivory, edge effects from road maintenance, fuel modification activities, or other threats do not directly or indirectly adversely affect *Piperia yadonii* and its habitat (USFWS, 2009).

Results of monitoring activities have determined that the protected populations of *Piperia yadonii* are of adequate size to be self-sustaining and to ensure their long-term persistence. This species is a perennial that exhibits dormancy, spending an undetermined period underground between seed germination and emergence of first leaf aboveground. The duration of dormancy specific to *Piperia yadonii* is not known but data on similar species indicate may be up to 4 years (Hutchings 1987). The 2004 Recovery Plan states that a minimum of 10 to 15 years of monitoring will likely be needed in order to define a population trend (USFWS, 2009).

Delisting Criteria:

Delisting Criterion 1) threats are reduced or eliminated so that protected populations are capable of persisting without significant human intervention or perpetual endowments are secured for management necessary to maintain the continued existence of the species. The

most outstanding management needs currently are: a) maintaining and restoring habitat through control of nonnative species (especially grasses and broom), and b) control of herbivory by deer and small mammals. (USFWS, 2019).

Delisting Criterion 2) a seed bank has been established at a recognized institution certified by the Center for Plant Conservation. (USFWS, 2019).

Delisting Criterion 3) all protected populations remain viable for at least 10 years to demonstrate long-term viability under a range of environmental conditions. Based on recent research by Graff (2006), we expect above-ground population size to fluctuate somewhat on an annual basis, based on response to amount and timing of rainfall. Even though this is a perennial species, the aboveground portion is herbaceous and dies back each year, and thus responds to some extent like an annual species. Therefore, a period of 10 years should be long enough to include most of the variability in rainfall that occurs in this region (Zedler & Black 1989; NOAA 2018). (USFWS, 2019).

Recovery Actions:

- Secure and protect existing populations and habitats that occur on private or unprotected lands (USFWS, 2004).
- Manage private and secured lands to control or eliminate threats to existing populations and their habitat (USFWS, 2004).
- Stimulate research on the biology of these species. Develop management strategies based on life-history research and species responses to vegetation management (USFWS, 2004).
- Determine other potentially suitable habitat areas that should be surveyed for additional populations, or that can be used for reestablishment or reintroduction of populations (USFWS, 2004).
- Use monitoring, research results, and assessment of potential threats to determine effectiveness of management actions (USFWS, 2004).
- Coordinate recovery actions with other listed species or species of concern (USFWS, 2004).
- Develop and implement a public outreach program (USFWS, 2004).
- Reevaluate recovery criteria and revise recovery plan based on knowledge obtained from research, monitoring, and management (USFWS, 2004).
- We recommend land managers continue monitoring of all known populations of *Piperia yadonii* and manage land uses for conservation of the species. More monitoring is necessary to determine any population trends due to the variability in above ground expression of the species. Long-term monitoring will aid in distinguishing between true population trends and changes in dormancy from year to year (Graff 2006) (USFWS, 2009).
- We recommend the County of Monterey develop a set of best management practices to work with private land owners to protect populations of *Piperia yadonii* and manage for the species (USFWS, 2009).
- We recommend research be undertaken to identify ways to reduce and minimize herbivory on the Monterey Peninsula (USFWS, 2009).
- We recommend continued efforts by landowners and land managers to reduce and remove non-native species (USFWS, 2009).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Secure funding for annual surveys and invasive species management for occurrences in each recovery area that are currently protected from development, but for which funding is absent or expected to be reduced in the future. 2. Promote the establishment of Yadon's piperia through seeding following the methodology of JMC and EWCG (2016, p. 3-7). Results of seeding are likely to take four or more years to determine success, and then require long term management of invasive species and litter. Seeding should be conducted proactively. 3. Create and maintain at least one deer exclusion area in each protected occurrence to ensure reproductive output of at least small portions of larger populations. (USFWS< 2021)

References

U.S. Fish and Wildlife Service. 2004. Recovery Plan for Five Plants from Monterey County, California. U.S. Fish and Wildlife Service, Portland, Oregon. xii + 159 pp

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

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed June 2016.

USFWS 2009. *Piperia yadonii* (Yadon's piperia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California . Accessed June 2016

USFWS. 2019. Recovery Plan for Five Plants from Monterey County, California, Amendment 1. USFWS, Pacific Southwest Region, Ventura, CA. 18 pp.

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

Designation of Critical Habitat for *Piperia yadonii* (Yadon's piperia). Final Rule. 72 FR 60410-60450 (October 24, 2007).

U.S. Fish and Wildlife Service. 2009. *Piperia yadonii* (Yadon's piperia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California

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

U.S. Fish and Wildlife Service. 2009. *Piperia yadonii* (Yadon's piperia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California. NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A."

U.S. Fish and Wildlife Service. 2009. *Piperia yadonii* (Yadon's piperia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California.

U.S. Fish and Wildlife Service. 2009. *Piperia yadonii* (Yadon's piperia)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service. 2004. Recovery Plan for Five Plants from Monterey County, California. U.S. Fish and Wildlife Service, Portland, Oregon. xii + 159 pp

USFWS. 2009. *Piperia yadonii* (Yadon's piperia) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service. 2004. Recovery Plan for Five Plants from Monterey County, California. U.S. Fish and Wildlife Service, Portland, Oregon. xii + 159 pp.

USFWS. 2019. Recovery Plan for Five Plants from Monterey County, California, Amendment 1. USFWS, Pacific Southwest Region, Ventura, CA. 18 pp.

USFWS. 2021. *Yadon's piperia* (*Piperia yadonii*) 5-Year Review: Evaluation and Summary. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California. 19 pp.

SPECIES ACCOUNT: *Platanthera integrilabia* (White fringeless orchid)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/13/2016; Southeast Region (R4) (USFWS, 2017)

Physical Description

White fringeless orchid is a perennial herb with a light green, 60 centimeter (cm) (23 inches (in)) long, stem that arises from a tuber. The leaves are alternate with entire margins and are narrowly elliptic to lanceolate in shape. The lower leaves are 20 cm (8 in) long and 3 cm (1 in) wide. The upper stem leaves are much smaller. The white flowers are borne in a loose cluster at the end of the stem. The upper two flower petals are about 7 millimeters (mm) (0.3 in) long and the lower petal (the lip) is about 13 mm (0.5 in) long. The epithet *integrilabia* refers to the lack of any prominent fringe on the margin of the lip petal. The plants flower from late July through September and the small narrow fruiting capsule matures in October (Shea 1992, page 23).

Taxonomy

White fringeless orchid was first recognized as a distinct taxon in 1941 when D.S. Correll described this plant as a subspecies of *Habenaria* (*Platanthera*) *blephariglottis* (Correll 1941, pages 153-157). C.A. Luer elevated the taxon to full species status in 1975 (Luer 1975, page 186). The currently accepted binomial for the species is *Platanthera integrilabia* (Correll) Luer.

Historical Range

U.S.: Alabama, Georgia, Kentucky, Mississippi, South Carolina, North Carolina, Tennessee. *Platanthera integrilabia* was originally known seven states. The species has been extirpated from North Carolina (Henderson and Cherokee Counties), and a population has been extirpated from one county in Georgia (Cobb County). We previously have reported that *P. integrilabia* historically occurred in Virginia, but based on information from Townsend (pers. comm. 2012), we no longer consider Virginia to be within the historic distribution of this species.

Current Range

U.S.: Alabama (9), Georgia (8), Kentucky (8), Mississippi (2), South Carolina (1), Tennessee (37). The species currently occurs within the Appalachian Plateau Physiographic Province in Kentucky, Tennessee, Georgia, and Alabama; the Coastal Plain Physiographic Province in Alabama and Mississippi; the Blue Ridge Province in Georgia and Tennessee (Shea 1992, page 19); and primarily in the Piedmont Physiographic Province in Georgia (Medley 1980; White 1998, pers. com. 1999; A. Shea pers. com. 1999; McCoy 2008, 2012; and Patrick pers. com. 2012).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual; R-selected

Dependency on Other Individuals or Species

Adult: Research on the mycorrhizal fungal relationships of *P. integrilabia* suggests that the symbiont's, specifically *Epulorhiza inquilina*, presence may play a key role in the rate of seed germination (Currah, Zettler and McInnis 1997; Yoder et al. 2000). *Platanthera integrilabia* is considered to be pollinated by diurnal Lepidoptera, especially swallowtails and/or sphingid moths.

Breeding Season

Adult: The plants flower from late July through September and the small narrow fruiting capsule matures in October (Shea 1992, page 23).

Reproduction Narrative

Adult: *Platanthera integrilabia* flowers from late July through early September but as early as June in the southern portion of its range (Alabama). Fruits usually mature in October (Luer 1975; Gleason & Cronquist 1991; Shea 1992). Each plant grows from a single rootstock or tuber. In the winter season, two tubers can be found on one plant; one large tuber and a smaller more recently formed tuber. By spring, the tuber from the previous season (larger) will die back, and the new smaller tuber will supply energy for the upcoming growing season. The formation of the "same" plant from a new tuber can cause the vegetative shoot to "move" up to 15 cm from the previous year's locale (Shea 1992; Zettler & Fairley 1990). The percentage of individuals flowering within a population is generally very low. Like many Orchids, *P. integrilabia* has pollinia (pollen sacs which adhere to pollinators) that transfer pollen from plant to plant. The primary chemical attractant, which is common, in orchid nectars with strong evening odors is linalool (Hill 1968). Only about 3% of the wind-dispersed seeds germinate, which means plants have to produce copious amounts of seeds to overcome the high seed/seedling mortality. Recent studies of the other factors leading to low reproductive capacity are herbivory, inbreeding depression, and lack of effective pollinators (Zettler & Fairley 1996 and Bailey 2001). Additionally, research on the mycorrhizal fungal relationships of *P. integrilabia* suggests that the symbiont's, specifically *Epulorhiza inquilina*, presence may play a key role in the rate of seed germination (Currah, Zettler and McInnis 1997; Yoder et al. 2000).

Habitat Type

Adult: *Platanthera integrilabia* is generally found in wet, flat, boggy areas in acidic muck or sand, and in partially, but not fully shaded areas at the head of streams or seepage slopes.

Habitat Vegetation or Surface Water Classification

Adult: Riverine habitat: Spring/Spring brook; Palustrine habitat: Bog/fen, Forested wetland, Herbaceous wetland, Riparian (NatureServe)

Geographic or Habitat Restraints or Barriers

Adult: Typical barriers for this species include uplands and bodies of water without margins that support shallow wetlands (NatureServe 2009; Major 2002).

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2012)

Habitat Narrative

Adult: *Platanthera integrilabia* grows in wet, boggy areas at the heads of streams and on seepage slopes. It is often associated with *Sphagnum* in partially, but not fully, shaded areas. Other common associates include: cowbane (*Oxypolis rigidior*), grass-of-Parnassus (*Parnassia asarifolia*), primrose-leaf stemless white violet (*Viola primulifolia*) and other orchids, particularly green wood orchid (*Platanthera clavellata*) and yellow-fringe orchid (*Platanthera ciliaris*) (Patrick pers. com. 2012).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Successful germination and establishment of *P. integrilabia* could be limited by dispersal of seeds into suitable sites where hyphae of appropriate fungal species are present to support a symbiosis that could be critical in the orchids early life cycle (Birchenko 2000, p. 36).

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Resiliency:

Current Resilience: Resilience refers to the ability of populations to withstand stochastic events, whether demographic, environmental, or anthropogenic. For this SSA, empirical data are not available to associate resilience categories with specific quantitative extinction risks or probabilities of persistence. Rather, we are limited to providing qualitative definitions of each resilience category based upon assumptions about population size, flowering, and connectivity, which are based on general plant population dynamics rather than actual research on *P. integrilabia*. Populations with low resilience are highly vulnerable to stochastic events and face a high risk of extirpation within the next few decades. Populations with moderate resilience are less likely to be extirpated within the next few decades, but require additional population increases (with help of regular habitat management and/or restoration) to become more self-sustaining and resilient to stochastic events. Populations with high resilience are unlikely to be extirpated within the next few decades in the absence of catastrophes or significant declines in habitat quality. Populations with very high resilience are the most robust and resistant to stochastic fluctuations. Summaries of the 50 delineated populations and their resilience categories are provided in Table 5.3. Twenty-two percent of the assessed populations were classified as having high or very high resilience while 66 percent of the populations were classified as having low resilience (Table 5.4). Approximately one third of the populations have no protection or management and the majority (76 percent) of those have low resilience (Table 5.4). (USFWS, 2021)

Representation:

Representation describes the ability of a species to adapt to changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity within and among populations and gauges the probability that a species is capable of adapting and/or acclimating to environmental changes. The more representation, or diversity, a species has, the

more capable it is of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range. To do this, we evaluated representation of *P. integrilabia* using EPA Level III Ecoregions (Omernik 1987, entire). Ecoregions are delineated based upon areas with similar biotic and abiotic phenomena including geology, landforms, soils, vegetation, climate, land use, and hierarchical level. *P. integrilabia* populations occur in five Level III Ecoregions: Blue Ridge (6); Piedmont (7); Ridge and Valley (1); Southeastern Plains (5); and Southwestern Appalachians (31) (Fig. 5.1; Table 5.5). Redundancy is greatest in the Southwestern Appalachians, which includes the Cumberland Plateau where the majority of *P. integrilabia* populations occur. Redundancy in the other ecoregions is comparatively lower; however, it is unclear how much this distribution has changed compared to the historical distribution of *P. integrilabia*. In addition to the low number of populations in the Blue Ridge, Piedmont, and Ridge and Valley ecoregions, all but three of these populations have low resilience; populations in the Southeastern Plains generally have low resilience and lack habitat protection with few exceptions (Figs. 5.1 and 5.2; Table 5.5). (USFWS, 2021)

Redundancy:

Redundancy describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resilience, and their distribution, redundancy gauges the probability that the species has a margin of safety to withstand or recover from catastrophic events (such as a rare destructive natural event or episode involving many populations). Catastrophic events could include, among others, frequent or severe fires, droughts, disease outbreaks, or prolonged flooding, each of which cause impacts at different spatial scales. It is worth noting that no information is currently available about soil seedbank formation or resilience for this species; lacking such data, it is difficult to predict long-term impacts of catastrophes. For *P. integrilabia* to maintain viability in the long term, the species needs to exhibit some degree of redundancy. As stated previously, there are 50 populations of *P. integrilabia* that have been observed within the past 20 years, and resilience of these populations is as follows: 5 – Very High; 6 – High; 6 – Moderate; and 33 – Low. The populations are spread across the range, although the majority are distributed in Tennessee and Kentucky (Fig. 5.1). *P. integrilabia* still occurs in most of the counties from which it is historically known. However, there are many low resilience populations in the eastern and southern parts of its range which may lead to reductions in the future redundancy (Fig. 5.1). Birchenko (2001, p. 37) determined there is currently no current indication of restricted gene flow between populations. However, genetic exchange between populations may be constrained in the future for a couple of reasons: (1) 54 percent of the populations exhibit low connectivity with other populations (i.e., no other populations within 10 kilometers) and (2) 30 percent of the populations have low or no flowering. Given the low numbers of individuals already occurring in many of these populations, especially in the southern and eastern populations (Fig. 5.1), it is far less likely that these populations can withstand acute catastrophic events. Redundancy is further threatened due to the lack of habitat protection for many of the populations occurring in the southwestern portion of the species range (Fig. 5.2). Limited redundancy of populations outside of the Southwestern Appalachians, many of which have low levels of resilience, suggests there is a greater risk of losing representation within these geographic regions, along with any potentially unique genetic or morphological traits these populations possess that might not be present in populations of the Southwestern Appalachians. Populations in these regions with conservation ranks of medium or higher could provide opportunities for focusing habitat and

population management efforts to increase their resilience, reducing the relatively higher level of extinction risk facing *P. integrilabia* at the edges of its geographic range. (USFWS, 2021)

Number of Populations:

65 occurrences over 6 states

Population Size:

Unknown

Additional Population-level Information:

Birchenko (2000, pp. 18-23, 47-48) analyzed genetic structure among 25 populations of *P. integrilabia*, distributed across Alabama, Georgia, Tennessee, and Kentucky. The majority (79 percent) of the genetic variation was present as variation within populations, while about 21 percent of the variation was attributable to differences among populations (Birchenko 2000, p. 29). While these results alone do not demonstrate that genetic variability in populations of *P. integrilabia* has been eroded by restricted gene flow, Birchenko (2000, pp. 34-40) cautioned that interactions between demographic and ecological factors could be a cause for some of the declines in *P. integrilabia* population sizes and could ultimately cause declines in the species genetic variation and increase differentiation among populations of *P. integrilabia*. Zettler and Fahey (1990, pp. 212-216) reported that only 2.8 percent to 4.6 percent of the plants within a population flower in any given year and of these, only 6.9 percent to 20.3 percent will set seed. This results in a very low production of seeds and, consequently, a limited ability to reproduce at most sites. Low reproductive potential combined with often small population sizes, likely contributes to low (potentially negative) population growth rates and increases potential for inbreeding depression and genetic bottlenecks. As noted above, herbivory (especially when targeted upon inflorescences, as is often the case) would further compound the threat of low reproductive potential and low seed set.

Population Narrative:

Due to different sampling techniques and count methods (flowering vs vegetative stems from year to year) trends are hard to detect. General observations of declines in plant numbers and numbers of flowering plants are reported from Kentucky, Georgia, and Tennessee (decline in the number of flowering plants at some of the largest sites) (USFWS 2013). Historically, there were at least 90 populations of *P. integrilabia*. Today the species is known or presumed extant at some 65 sites across its range. The majority of known sites consist of fewer than 100 plants, although some sites have been reported to contain 500-1000 plants at some point in their history. Reports of sites containing over 1000 plants are not unprecedented, but are rare. Direct comparisons of historical and current population size estimates are difficult for the majority of known sites, in that observations are frequently reported as flowering stems one year, and vegetative plants the next, with many years elapsing in between observations made by different individuals. Also complicating direct comparisons within sites among years is the fact that conclusive identification of *P. integrilabia* requires flowers therefore vegetative counts (depending upon the observers familiarity with the species) may be suspect and could potentially include other species of *Platanthera* which sometimes co-occur with *P. integrilabia*. Nonetheless, some apparent trends form the basis of sustained and some heightened concerns about the species status. In Alabama, declines have been reported at three of eight known sites, and a fourth has not been observed despite repeated surveys (A. Schotz pers. com. 2009; S. Miller pers. com. 2008). Four sites in this state have not been observed since the early 1990s (A.

Schotz, pers. com., 2009); though, a new occurrence was discovered on private lands in Clay County in 2010 (A. Schotz, pers. com., 2011). In Kentucky, D. White (pers. com., 2005 and 2007) reported declines across most of the eight known populations in that state, often with no clear indication of what had caused the decline. D. White (pers. com., 2009) provided the following synopsis: while there is concern about the degrading habitat where these plants occur, the site ranks have not significantly declined [with the exception of] (one site); populations are at about the same level of viability as 10 years ago.

Threats and Stressors

Stressor: Development

Exposure:

Response:

Consequence:

Narrative: Shea (1992, pp. 25-28) reported that several *P. integrilabia* populations have been lost to habitat altering activities such as road construction, residential and commercial construction, and soil and site hydrology altering projects that reduced site suitability for the species. Shea estimated that these activities continued to threaten at least 50 percent of the remaining populations in 1992. In Tennessee, three of 48 known occurrences have been extirpated from the construction of small private lakes (McCoy 2008, p. 3). Loss of sites to residential and other construction activities remains a potential threat to privately owned populations not managed for conservation.

Stressor: ATV traffic

Exposure:

Response:

Consequence:

Narrative: Shea (1992, p. 28) concluded that all-terrain vehicles (ATVs) damaged or killed some plants at three sites in Tennessee, and identified ATVs as a potential threat at three additional sites across the species range.

Stressor: Collection (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Collecting for scientific, recreational, or commercial purposes has been determined to be the cause for extirpation of the white fringeless orchid at its type locality (Ettman and McAdoo 1979 cited in Zettler and Fahey 1990, p. 212), and recent evidence demonstrates that collection remains a threat to this species (USFWS, 2016).

Stressor: Disease (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Fungal pathogens have been identified as a threat to white fringeless orchid (USFWS, 2016).

Stressor: Herbivory (USFWS, 2016)

Exposure:**Response:****Consequence:**

Narrative: Inflorescence herbivory is presumably by deer (Zettler and Fairey 1990, p. 212–214). Flower herbivory has been reported at over onethird of extant occurrences and likely is a factor threatening most white fringeless orchid occurrences (Shea 1992, pp. 27, 61, 71–77, 95–97; TDEC 2012, p. 3; KSNPC 2014; TDEC 2014), especially where low numbers of plants are present. Tuber herbivory or soil disturbance by feral hogs has been reported at multiple occurrences, including the site harboring the largest known white fringeless orchid population (Zettler 1994, p. 687; USFS 2008, p. 54) (USFWS, 2016).

Stressor: Small population size (USFWS, 2016)

Exposure:**Response:****Consequence:**

Narrative: Small population sizes characterize a majority of occurrences throughout the species' geographic range, due to their diminished capacity to recover from loss of individuals or low reproductive output resulting from other threats (Zettler et al. 1996, p. 22) (USFWS, 2016).

Stressor: Species dependencies (USFWS, 2016)

Exposure:**Response:****Consequence:**

Narrative: The species' dependence on a limited number of Lepidoptera (Zettler et al. 1996, p. 16) and a single species of fungi (Currah et al. 1997, p. 30) to complete its life cycle make it vulnerable to disturbances that diminish habitat suitability for these taxa as well (USFWS, 2016).

Stressor: Climate change (USFWS, 2016)

Exposure:**Response:****Consequence:**

Narrative: Climate has changed in recent decades in the southeastern United States, and the rate of change likely will continue to increase into the future (Karl et al. 2009, pp. 111–112). The potential for adverse effects to the white fringeless orchid, either through changes in habitat suitability or effects on populations of pollinators or mycorrhizal fungi, is likely to increase as climate continues to change at an accelerating rate (USFWS, 2016).

Stressor: Logging (USFWS, 2021)

Exposure:**Response:****Consequence:**

Narrative: Logging is a risk to *P. integrilabia* populations because it changes canopy cover, increases likelihood of invasive plant species encroachment, causes direct habitat destruction, and alters local hydrology and soil moisture. In order to assess the risk of logging to each *P. integrilabia* population, we summed loss of forest cover (i.e., deciduous, mixed, and woody wetlands) in each county occupied by *P. integrilabia* using National Land Cover Database (NLCD) change, a raster data set which displays changes in major land cover class from 2006 to 2011 (NLCD 2011). In order to avoid double counting potential impacts from urbanization (see above),

we did not include any change from forest cover that occurred due to urban development. (USFWS, 2021)

Recovery

Reclassification Criteria:

Recovery Priority Number: 8

Delisting Criteria:

1. Monitoring over a 10-year period demonstrates stable or increasing population growth rates for at least 26 protected populations with resilience levels of moderate to very high (as described in the SSA). To ensure adequate representation and redundancy, these populations must be distributed among Environmental Protection Agency (EPA) Level III Ecoregions as shown in the following table. (Addresses Factors A and E.) (USFWS, 2023).
2. Written management agreements have been reached with partners/landownersthat allow for sustained monitoring and management of white fringeless orchid populations that demonstrate moderate to very high resilience. (Addresses Factor A.) (USFWS, 2023).
3. Alternatively, the species could be considered for delisting if 40 populations with resilience levels of moderate to very high (as described in the SSA), protected or unprotected, are distributed among EPA Level III Ecoregions where the species occurs. At least half of these populations must have resilience levels of high or very high. (Addresses Factor A and E.) (USFWS, 2023).

Recovery Actions:

- 1. Work with partners to protect, restore, and manage habitat where populations are extant or could be restored (USFWS, 2023).
- 2. Conduct monitoring and research to increase knowledge about biology and ecology of white fringeless orchid to facilitate the development of scientifically sound management plans and models for conducting population viability analyses (USFWS, 2023).
- 3. Conduct surveys to identify new populations and assess occupancy at historically occupied sites (USFWS, 2023)
- 4. Increase the representation and genetic diversity of ex situ collections of white fringeless orchid in seedbanks (USFWS, 2023).
- 5. Using seeds or propagated plants, augment protected populations that are unable to grow in response to habitat management due to low population size, or introduce populations into suitable, but unoccupied, managed habitat on conservation lands (USFWS, 2023).
- 6. Coordinate with partners to promote white fringeless orchid recovery and increase public awareness of the species and its conservation (USFWS, 2023).

Conservation Measures and Best Management Practices:

- Recovery Strategy: The primary recovery strategy for white fringeless orchid is to ensure that resilient populations exist throughout the species' range. To achieve this the Service must cooperate with partners to carry out recovery actions listed below in Actions Needed. The purposes of completing these actions are to: • reduce threats to the species' long-term viability by protecting,

restoring, and managing habitat where populations are extant or could be restored • conduct monitoring and research to increase knowledge of reproductive biology, life history, and ecological factors regulating population growth • survey potential habitat to identify new populations • maintain germplasm using ex situ conservation methods and propagate plants for augmenting or restoring populations • increase public awareness of the species and its conservation (USFWS, 2021a)

References

USFWS 2012. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Platanthera integrilabia* (White Fringeless Orchid). U.S. Fish and Wildlife Service, Region 4 (Southeast Region)

April 9, 2012

15 p.

USFWS. 2017. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed March 2017.

15 p. USFWS. 2021. Species status assessment report for *Platanthera integrilabia* (white fringeless orchid), Version 1.0. March 2021. Atlanta, Georgia.

USFWS. 2012. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Platanthera integrilabia* (White Fringeless Orchid). U.S. Fish and Wildlife Service, Region 4 (Southeast Region)

USFWS. 2016. Endangered and Threatened Wildlife and Plants

Threatened Species Status for *Platanthera integrilabia* (White Fringeless Orchid). Final rule. 81 FR 62826 - 62833 (September 13, 2016).

USFWS. 2021. Species status assessment report for *Platanthera integrilabia* (white fringeless orchid), Version 1.0. March 2021. Atlanta, Georgia.

USFWS. 2021a. Draft Recovery Plan for White Fringeless Orchid (*Platanthera integrilabia*). Atlanta, Georgia.

USFWS. 2023. Recovery Plan for White Fringeless Orchid (*Platanthera integrilabia*). Atlanta, Georgia.

SPECIES ACCOUNT: *Platanthera leucophaea* (Eastern prairie fringed orchid)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

This plant is 8 to 40 inches tall and has an upright leafy stem with a flower cluster called an inflorescence. The 3 to 8 inch lance-shaped leaves sheath the stem. Each plant has one single flower spike composed of 5 to 40 creamy white flowers. Each flower has a three-part fringed lip less than 1 inch long and a nectar spur (tube-like structure) which is about 1 to 2 inches long.

Taxonomy

The western prairie white-fringed orchid (*Platanthera praeclara*) is now distinguished from *P. leucophaea*. *Platanthera leucophaea* is primarily east of the Mississippi River and *P. praeclara* is essentially west of that river. (NatureServe, 2015)

Historical Range

In addition to the current range, historically occurred in New York; is extirpated in Pennsylvania where it once also occurred.

Current Range

U.S. States: Illinois, Indiana, Iowa, Maine, Michigan, Missouri, Ohio, Oklahoma, Virginia, Wisconsin; Canada. The eastern prairie fringed orchid's distribution has not changed appreciably since 1991, however, three newly discovered populations were added since the last 5-year review in 2016 (USFWS 2016). (USFWS, 2020)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Dependency on Other Individuals or Species

Adult: Three species of hawkmoths (*Eumorpha pandorus*, *Eumorpha achemon*, and *Sphinx eremitis*) have been verified as eastern prairie fringed orchid pollinators (Cuthrell 1994, Crosson et al. 1999, Cuthrell et al. 1999, Pollack 2009).

Breeding Season

Adult: peak flowering season in June or July and again when fruits were mature in September (USFWS, 2016)

Key Resources Needed for Breeding

Adult: Zettler and others (2001, 2005) determined that the mycorrhizal fungus *Ceratophora goodyerae-repentis* promotes germination of eastern prairie fringed orchid seed (Zettler et al.

2005) and can sustain mature plants (Zettler et al. 2001). The fungus *C. pernatena* has also been recovered from mature eastern prairie fringed orchids (Zettler et al. 2001). Zettler et al. (2005) also determined that photosynthesis is supplemented by mycotrophy throughout adulthood by *C. goodyerae-repentis* and *C. pernatena*, and *Epulorhiza* to a lesser degree.

Reproduction Narrative

Adult: The plant has capacity for annual regeneration of the tuber rootstock and associated buds, making individual plants potentially long-lived. The underground tuber develops a bud and the precursors of a flowering stalk during the growing season the year before flowering (see Figure 4). The leaves and a developing flower cluster begin to emerge above ground in May of the following growing season. Night flying hawkmoths pollinate the nocturnally fragrant flowers of the white-fringed orchids (Bowles 1983, 1985). Reproduction by vegetative spread is apparently rare. Visiting hawkmoths receive pollen on their proboscises as they ingest nectar from the flower's long nectar spurs. A 1998 survey of large sites in Michigan and Ohio identified the following species carrying eastern prairie fringed orchid pollen: *Eumorpha pandorus*, *Eumorpha achemon*, and *Sphinx eremitis* (D. Cuthrell, Michigan Natural Features Inventory, in litt.1998). Some Illinois records of larval host plants for *Eumorpha pandorus* and *Eumorpha achemon* are *Ampelopsis* spp., and *Vitis* spp.; and for *Sphinx eremitis* are *Monarda* spp., *Mentha* spp., *Lycopsis* spp., and *Salvia* spp. The garden pest tomato and tobacco hornworms have been observed visiting the orchids. A number of additional moth species have been identified as potential pollinators by correlating their proboscis length with the depth to nectar in the eastern prairie fringed orchid's nectar spur. Additional field surveys are needed to confirm their status as pollinators. White-fringed prairie orchid blossoms often rise just above the height of the surrounding grasses and sedges. The more exposed flower clusters are more likely to be visited by the hawkmoth pollinators (Bowles 1985), though they are also at greater risk of being eaten by deer. Following pollination, white-fringed orchid seed capsules produce thousands of minute, lightweight seeds, that are dispersed by the wind after the capsules dry out and crack open, and release the seeds. (USFWS, 1999) Dr. Bell found that based on the demographic transition matrix pooled over all populations and years, the eastern prairie fringed orchid (in Illinois) has an increasing population growth rate ($\lambda = 1.1391$) (Bell et al. 2015). The mean generation time (or average age for first reproduction of a cohort) for the eastern prairie fringed orchid is 3.95 years (Bell et al. 2015). However, only about 30% of plants live more than one year after entering the demographic dataset (Bell et al. 2015). Survival and flowering probability differ among plant stages (juvenile, flowering, and vegetative (vegetative plants are nonflowering plants that flowered at least once before)) and generally increase with plant size. Most plants stay in a respective stage for about 1 year, however some plants (< 1%) can repeatedly flower for up to 6 years (Bell et al. 2015). Additional research results (Bell et al. 2015) include: Most plants live only 1 year, or they live one year after they are found at a site and also included in the demographic dataset. Specifically, 98% of plants live five years or less and 2% live 6 to 12 years. Most plants stay in a respective stage only for 1 year. Flowering and vegetative (nonflowering plants that flowered at least once before) plants can stay in that stage for up to 6 years. Most plants are never dormant (94%). Of those that are dormant (6%), 67% are dormant for a year, 20% are dormant for 2 years, 9% are dormant for 3 years, 2% are dormant for 4 years, 0.5% are dormant for 5 years. Survival is the highest in relatively large plants. Large juveniles are most likely to flower the following year. Plants that are hand pollinated have a slightly higher pod production rate ($p = 0.42$). There is estimated to be 4,500 seeds in each seed capsule. If all of the offspring of one plant were found, we would expect to find 22 juveniles. The proportion of survival for this orchid by herbivory level: Five categories were determined

(none, slight leaf damage, slight flower damage, severe flower damage, entire inflorescence destroyed). Plants with no herbivory had lower survival than those with slight flower damage. Herbivory does not appear to present a problem based on overall survival information. The effects of herbivory on flowering the following year does not appear to have a clear effect. Prescribed burning increases population survival and does not affect the number of flowering plants or pods. Populations with low management needs have a higher mean survival rate. (USFWS, 2016)

Habitat Type

Adult: Mesic to wet prairies and wet sedge meadows. Peripheral habitat includes sedge-sphagnum bog mats around neutral pH kettle lakes, and fallow agricultural fields. Wet ditches and railroad rights-of-way also serve as refugia. This species' winter-dormant tubers are adapted to dormant-season prairie fires; such fires and high precipitation levels appear to promote flowering.

Dependencies on Specific Environmental Elements

Adult: Susceptible to changes in water table; populations along the shores of the Great Lakes are threatened by high water levels. This species' winter-dormant tubers are adapted to dormant-season prairie fires; such fires and high precipitation levels appear to promote flowering.

Habitat Narrative

Adult: The eastern prairie fringed orchid occurs in a wide variety of habitats, from mesic prairie to wetland communities such as sedge meadows, marsh edges and even bogs. It requires full sunlight for optimum growth and flowering, which restricts it to grass- and sedge-dominated plant communities. The substrate of the sites where it occurs ranges from more or less neutral to mildly calcareous (Case 1987, Sheviak 1974, Bowles 1983). These habitats occur across six physiographic regions. The unglaciated Ozark region supports sedge meadow habitat, from which the eastern prairie fringed orchid is apparently extirpated. Kansan glacial soils support prairie habitat, primarily west of the Mississippi River. East of the Mississippi River, Wisconsinan glacial soils support prairie, sedge meadow, and peatland habitat. The lake plains of the Lake Michigan, Lake Huron, and Lake Erie basins support prairie habitat. Disjunct populations also occur in unglaciated sedge meadow, and formerly occurred in unglaciated prairie in Oklahoma. (USFWS, 1999)

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Following pollination, white-fringed orchid seed capsules produce thousands of minute, lightweight seeds, that are dispersed by the wind after the capsules dry out and crack open, and release the seeds. (USFWS, 1999)

Population Information and Trends**Population Trends:**

Stable. Inferred from information (USFWS, 2020)

Species Trends:

Decline

Population Growth Rate:

Slow

Number of Populations:

96 (USFWS, 2020)

Resistance to Disease:

Low

Adaptability:

Low

Population Narrative:

Three new populations have been recorded since the last review resulting in a total of ninety-six populations range wide (USFWS, 2020). Per state, Illinois supports forty-two *P. leucophaea* populations (five are highly viable), Indiana supports one population, Iowa supports five populations, Maine supports one population, Michigan supports eighteen populations (one is highly viable), Missouri supports one population, Ohio supports ten populations, Virginia may support one population, and Wisconsin supports seventeen populations (six are highly viable). (USFWS, 2020)

Threats and Stressors

Stressor: Present or threatened destruction, modification or curtailment of its habitat or range (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Most eastern prairie fringed orchid populations have been lost through conversion of habitat to cropland and pasture. Drainage and development pose threats to this species' habitat. In addition, late-successional (i.e., high quality natural areas free of invasive species) prairie remnants supporting this species require management to reduce cover of woody vegetation. Fire and other management techniques that mimic natural disturbance may be required to control or eliminate invasive species and to maintain stable late successional vegetation. Most sites within the species range need continual management. In addition, if past actions have destroyed some ecosystem function (i.e., natural drainage) then management may be needed to mimic the lost function. Lack of appropriate natural areas management threatens populations regardless of their legal protection status (USFWS 1989). (USFWS, 2016)

Stressor: Overutilization for commercial, recreational, scientific, or educational purposes (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Native terrestrial orchids are rarely grown from seed. Adult plants are often sought for scientific and commercial purposes or, for gardens and therefore are susceptible to collection. Smaller populations of eastern prairie fringed orchids can be negatively impacted by collecting.

Due to high human population densities in some parts of the range of the eastern prairie fringed orchid, it can be subject to collection pressures. In the past, populations of eastern prairie fringed orchids in Michigan and Illinois have been impacted by removal of plants (USFWS 1989). (USFWS, 2016)

Stressor: Disease or predation (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Although no threats were identified under this listing factor when the species was listed (USFWS 1989), an increase in deer populations in portions of the species range (e.g. Illinois) has resulted in an increased impact from herbivory of eastern prairie fringed orchid flowers which reduces or eliminates the plants ability to reproduce. In Illinois, deer cages are provided by the Fish and Wildlife Service if the volunteer stewards believe their blooming eastern prairie fringed orchid plants would benefit from deer caging. In recent years, destruction of adult flowering plants later in the season (after seed production and before seed dispersal) from voles has been documented at many Illinois populations. Efforts to cage for voles has provided limited success. (USFWS, 2016)

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Protection of threatened plants on privately-owned lands is extremely limited in most states throughout the eastern prairie fringed orchid's range, leaving those populations vulnerable to habitat destruction and extirpation (USFWS 1989). Currently and range wide, 43 of 98 existing populations, have full legal land protection (USFWS 2014). (USFWS, 2016)

Stressor: Other natural or manmade factors affecting its continued existence (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: The eastern prairie fringed orchid's dependence upon hawkmoths for pollination makes it vulnerable to changes in these insect populations. The status of most hawkmoth species is poorly known. Pollinator populations may be adversely affected by pesticides and loss of habitat (USFWS 1989). (USFWS, 2016)

Stressor: Climate Change (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: Climate change will be a particular challenge for endangered, threatened and other at-risk species because the interaction of additional stressors associated with climate change and current stressors may push them beyond their ability to survive (Easterling and Karl 2000). In addition, populations of some species that are near the southern end of the range may be at particular risk (IPCC 2014). While there is uncertainty about the exact nature and severity of climate change related impacts anticipated within the eastern prairie fringed orchid's range, a number of scientific studies project that there will be increased duration and intensity of heat

waves in summer, higher levels of humidity and evaporation; changing patterns of precipitation with fewer rain events of greater intensity; increased frequency and more severe dry spells; and more flooding from heavy rains (Easterling and Karl 2000; Ebi and Meehl 2007; Hall and Stuntz 2007; IPCC 2014; NCA 2014). Research has suggested that climate change may also negatively impact pollinator species if the plants and their pollinators respond differently to climate change (NRC 2007; Earthwatch Institute 2006). These climatic changes may threaten the eastern prairie fringed orchid in a variety of direct and indirect ways. However, climate changes will likely affect phenological timing, availability of suitable habitat, inter-specific relationships with pollinators and mycorrhizae associates, and threats from invasive species. Specific predictions of vulnerability or ability to shift ranges to suitable habitat in response to climate change based on life-history traits are frequently found to be species specific, and not widely applicable (Angert et al. 2011). In an effort to predict the potential range shift of the eastern prairie fringed orchid under climate change, Dr. Pati Vitt (2007) used modeling to predict the climate in Illinois in 2095. Dr. Vitt's (2007) research suggests that the predicted range of the eastern prairie fringed orchid will be concentrated northwest of its current range (Vitt 2007). The current areas of concentration for this species are around the Great Lakes. In the future, Michigan and Canada may be the best locations for this species considering climate change (Vitt 2007). The range is predicted to shift out of the Midwest and up towards the northeast (Vitt 2007). Close monitoring of *P. leucophaea* populations will help detect the species response to climate change and allow for consideration of management options. (USFWS, 2016)

Recovery

Delisting Criteria:

1. Twenty-two populations are distributed across plant communities and physiographic regions within the historic range of the species (See Table 5 for distribution of these populations). (USFWS, 1999)
2. Each of these 22 populations is highly viable. A highly viable population typically has more than 50 flowering plants; a population trend that is stable or increasing over a monitoring period of 5 years; available habitat of at least 50 hectares (125 acres) in size; assurances of ongoing management to reduce impacts from drainage, invasive non-native plant species or woody vegetation encroachment; and protection through long-term conservation easements, legal dedication as nature preserves, or other means. (USFWS, 1999)

Recovery Actions:

- 1. Protect habitat: The highest priority recovery actions for the eastern prairie fringed orchid are acquiring legal protection of habitat, and managing habitat. Protecting habitat through legal designation is recovery action 1 and identified as a priority 1 action (i.e., an action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future) (USFWS 1999). In most states, the highest available form of legal protection consists of conservation easements under state nature preserve acts (Pearsall 1984). Because only 43 of the 98 (44%) extant eastern prairie fringed orchid populations have legal land protection status, protection under state nature preserve acts should be pursued for the remaining populations. For states that do not have active nature preserve acts (e.g., Michigan), other forms of conservation easements that can be held by private organizations should be sought. Another option available to private landowners is conveyance of property rights to public or private conservation agencies that will provide

- legal protection and management. (USFWS, 1999; USFWS, 2016)
- 2. Manage habitat to support stable or increasing populations of the orchid: Because sites supporting orchid populations may require varying degrees of active management to maintain or enhance orchid populations, habitat management was identified in the species recovery plan as a priority 1 action. Only 4 of the 98 extant sites are considered without management need, a decrease from 13 in 2007. Currently, only 22 of the 98 known sites are in a late-successional stage. Management techniques needed may include prescribed burns, or brush and invasive species removal depending on the site condition. While habitat is being managed at many eastern prairie fringed orchid sites across the species range, habitat management is an ongoing activity that will have varying degrees of need based on the level of woody species encroachment and invasion by non-native plant species. (USFWS, 1999; USFWS, 2016)
 - 3. Increase the size and number of existing population: Recovery action 3 (increasing the size and number of populations) needs to be implemented continuously. As discussed above, through the removal of encroaching woody vegetation, eastern prairie fringed orchid habitat may be increased which, in turn, may lead to population expansion. The number of pollinator visits to small orchid populations may be a limiting factor for seed production at a particular site. Handpollination should be used where natural pollination is believed to be infrequent or absent in order to maximize seed production. Hand-pollination and seed dispersal appear to provide cost effective methods for augmenting existing populations (action 3.1) and reintroducing or introducing new populations (action 3.2) in appropriate habitat that is legally protected (USFWS 1999). (USFWS, 1999; USFWS, 2016))
 - 4. Monitor the status of known populations. (USFWS, 1999)
 - 5. Conduct research needed to identify recovery actions: Much has been learned about the eastern prairie fringed orchid since its listing and completion of the Federal recovery plan. However, there is still a need for greater understanding of the species life history requirements, specifically the species' pollinators and seed germination. Three species of hawkmoths (*Eumorphia pandorus*, *Eumorphia achemon*, and *Sphinx eremitis*) have been verified as eastern prairie fringed orchid pollinators (Cuthrell 1994, Crosson et al. 1999, Cuthrell et al. 1999, Pollack 2009). However, little is known about the hawkmoths' distribution, population levels, management needs, or reproduction. Research to gain greater understanding of these aspects of the pollinators will assist in the recovery of the eastern prairie fringed orchid (USFWS 1999, action 5.2). Research to date has determined that the mycorrhizal fungus *Ceratorhiza goodyerae-repentis* promotes the germination of eastern prairie fringed orchid seed (Zettler et al. 2005) and can sustain mature plants (Zettler et al. 2001). In addition, the fungus *C. pernacatena* has also been recovered from mature eastern prairie fringed orchids (Zettler et al. 2001), suggesting that the species may associate with both *C. goodyerae-repentis* and *C. pernacatena* when mature (Zettler et al. 2005). Further research is needed to determine the extent that eastern prairie fringed orchids require these fungal species throughout its range. In addition, research to determine if *C. goodyerae-repentis* can be used to inoculate seedlings, introduce these orchids into potential restoration sites, and propagate eastern prairie fringed orchids ex situ is needed (USFWS 1999, action 5.3). (USFWS, 1999; USFWS, 2016)
 - 6. Update population ranks and identify populations to be restored to higher levels of viability: The three population viability assessments cited in this review are based on field surveys conducted between 1990 and 1998, from 1999 to 2007, and from 2008-2014 (USFWS 1999, Bell 2008, USFWS 2014). The data collected in the population viability assessments provide an accurate and distinct update of the status of the eastern prairie

fringed orchid across the range of the species and are integral in completing this review. Assessment of the progress toward recovery through updates to the population viability assessment rankings should be completed annually, as described under action 6.1 (USFWS 1999). (USFWS, 1999; USFWS, 2016)

- 7. Track the progress towards recovery. (USFWS, 1999)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: The Service provides the following recommendations:
1. Protect habitat. 2. Manage habitat to support *P. leucophaea* populations through prescribed burning, control of exotic invasive species, etc. 3. Annual census (counting the number of blooming plants per year) of all *P. leucophaea* populations range wide. 4. Recruit Volunteers to annually census 17 of the 18 *P. leucophaea* populations in Michigan. 5. Increase the size and genetic diversity of existing populations through cross pollinating between populations and moving seed between populations. 6. Continue research to identify and evaluate the effectiveness of recovery actions.

References

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

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed June 2016. USFWS. 2020. 5-YEAR REVIEW Eastern Prairie Fringed Orchid (*Platanthera leucophaea*). 22 pp.

USFWS. 2016. Eastern Prairie Fringed Orchid (*Platanthera leucophaea*)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Chicago, Illinois. 62 pp. https://ecos.fws.gov/docs/five_year_review/doc5685.pdf. USFWS. 1999. Eastern Prairie Fringed Orchid (*Platanthera leucophaea*) Recovery Plan. Fort Snelling, Minnesota. 62pp.

USFWS. 2020. 5-YEAR REVIEW Eastern Prairie Fringed Orchid (*Platanthera leucophaea*). 22 pp.

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Chicago, Illinois. 62 pp. https://ecos.fws.gov/docs/five_year_review/doc5685.pdf

U.S. Fish and Wildlife Service. 1999. Eastern Prairie Fringed Orchid (*Platanthera leucophaea*) Recovery Plan. Fort Snelling, Minnesota. 62pp.

SPECIES ACCOUNT: *Platanthera praeclara* (Western prairie fringed orchid)

Species Taxonomic and Listing Information

Listing Status: Threatened; 09/28/1989; Great Lakes-Big Rivers Region (R3) (USFWS, 2016)

Physical Description

A perennial herb with stems that can grow to 1.2 m tall from an underground tuber. Inflorescences are large and showy, with up to 2 dozen white flowers arranged on a spike up to 7.5 dm long. Each flower has 3 petals, the lowest one much larger than the others and divided into 3 conspicuously fringed lobes (NatureServe, 2015).

Taxonomy

Platanthera, included in the genus Habenaria by some taxonomists, comprises approximately 200 species of temperate and tropical North Africa, North America, Central America, and Eurasia (Airy Shaw 1973, Luer 1975). There are 24 species, 36 taxa, and 5 named hybrids of Platanthera in North America, north of Mexico (Luer 1975). Previously, the species was included in a broader taxonomic concept of *P. leucophaea* (USFWS, 1996).

Historical Range

Published accounts and herbarium records suggest *P. praeclara* was widespread and perhaps locally common prior to European settlement (Bowles and Duxbury 1986). Historically, Brownell (1984) and Lobeck (1957) suggest western prairie fringed orchid was distributed throughout much of the western Central Lowlands and eastern Great Plains physiographic provinces of the central United States and Interior Plains in extreme south-central Canada (USFWS, 2009).

Current Range

Inhabits the Red River Valley of northern Minnesota, south in the Great Plains through the eastern Dakotas, central Nebraska, eastern Kansas, and northeastern Oklahoma; eastward through southern Minnesota, Iowa, and northern Missouri and in Manitoba. The eastern limit roughly corresponds to the Mississippi River (Watson, 1989; Bowles and Duxbury, 1986) (NatureServe, 2015). Minor changes to the spatial distribution of the species have occurred since the previous five-year review was published (Fig. 1, USFWS 2009). Fox et al. (2015) suggest there may be a northward shift in the range of the western prairie fringed orchid due to the relative success of the Canadian and United States populations in the Red River Valley (251A in Figure 1 below) and Lake Agassiz-Aspen Parklands ecoregions (222N) (p. 1000). Currently, there are 299 extant western prairie fringed orchid populations across Iowa, Kansas, Minnesota, Missouri, Nebraska, and North Dakota. Orchid populations were documented in three additional counties (two in Nebraska and one in Minnesota); however, the orchid is now presumed extirpated from five counties (two in Iowa, one in Nebraska, and two in Kansas) since the previous 5-year review. (USFWS, 2021)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources**Reproductive Strategy**

Adult: sexual (USFWS, 2021)

Lifespan

Adult: 3 - 8 years (USFWS, 1996)

Dependency on Other Individuals or Species

Adult: Wild cherry sphinx (*Sphinx drupiferarum*) (Larval Host: *Prunus* sp., *Malus* sp.), Hermit sphinx (*Lintneria eremitus*) (Larval Host: *Mentha* sp.), Achemon sphinx (*Eumorphia achemon*) (Larval Host: *Vitis* sp.), Spurge hawkmoth (*Hyles euphorbiae*) (non-native) (Larval Host: Leafy spurge (*Euphorbia esula*), Bedstraw hawkmoth (*Hyles gallii*) (Larval Host: Evening Primrose Family (*Onagraceae*), Madder Family (*Rubiaceae*)), White-lined sphinx (*Hyles lineata*) (Larval Host: Evening Primrose Family (*Onagraceae*), Four-o'clock Family (*Nyctaginaceae*)), Plebian sphinx (*Paratraea plebeja*) (Larval Host: Unknown). (USFWS, 2021)

Breeding Season

Adult: June - July (USFWS, 1996)

Key Resources Needed for Breeding

Adult: Mycorrhizal fungi, insect pollinators - especially sphinx moths (USFWS, 2016)

Other Reproductive Information

Adult: Friesen and Westwood (2013, p. 14) found a significant positive correlation between percent pollinaria removed and two meteorological variables that influence sphinx moth activity, wind speed and temperature; pollinaria removal was reported to be highest when wind speeds were 2.94 m/s. While Friesen and Westwood found no apparent relationship between sphinx moth activity and weather conditions, Eisikowitch and Galil (1971) found that effective sphinx moth pollination flights did not occur when wind speeds were greater than 3 m/s (p. 675). Because orchid populations are generally in open, exposed prairie areas, sphinx moths may prefer to seek nectar in sheltered areas during times of high winds. If high winds occur during the short bloom period of the orchid, there may be an insufficient number of sphinx moth visits required for seed capsule production (Borkowsky and Westwood 2009, p. 116). Winds across much of North America have been increasing since 2010 (Zeng et al. 2019, p. 979), which may have implications for western prairie fringed orchid seed production if sphinx moth pollination activities are negatively impacted by wind speeds greater than 2.5 m/s. Finally, in contrast to effects of wind and temperature, a significant negative correlation between percent pollinaria removed and relative humidity was also observed (Friesen and Westwood 2013, p. 14). (USFWS, 2021)

Reproduction Narrative

Adult: There is some evidence of vegetative reproduction (plants growing very close to each other), but based on examination of below ground structures vegetative reproduction is probably a rare event and relatively unimportant (NatureServe, 2015). This species is dependent on mycorrhizal fungi, especially for seed germination and for nutritional support before plants are capable of photosynthesis. Pollination is required for seed production. Western prairie

fringed orchid is pollinated by a few species of sphinx moths. Some observations suggest that non-sphingid moths may cause pollination in *P. praeclara*. Annual mortality rates of monitored plants were as low as 1.2 % and, in a drought year, as high as 13.5 % (Sather 1997) (USFWS 2009). Two months of vegetative growth may pass before an inflorescence will fully develop on a flowering plant. Plants bloom from mid-June in the southern portion of the range to late July in the northern portion. Most plants observed over a 7-year period that included both droughty conditions and flooding in this study area were present aboveground less than three years, and once absent, plants rarely reappeared (Sieg and King 1995). Although a small number of orchids on the Shewen National Grassland appeared aboveground every year for eight years, a predictable pattern in life states was not apparent (USFWS, 1996). Fox et al. (2013, p. 321) confirmed that western prairie fringed orchids do not produce seed capsules asexually or via self-fertilization. As such, pollinators are essential for seed capsule production and population growth. Pollinaria are often removed from the flowering orchid when the sphinx moth feeds on the nectar, but they can also be removed when wind is strong enough to brush the orchid against nearby vegetation (Borkowsky and Westwood 2009, p. 116). When pollinaria are brushed against nearby vegetation, fertilization does not occur, and seed capsules are not produced. (USFWS, 2021)

Habitat Type

Adult: Terrestrial, wetland (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Tallgrass prairie, sedge meadow (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Periodic disturbance, full sunlight (NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Flooding (USFWS, 2009)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe, 2015)

Dependency on Other Individuals or Species for Habitat

Adult: Mycorrhizal fungi, especially *Ceratorhiza* spp. (USFWS, 2009)

Habitat Narrative

Adult: This species is most commonly found in full sun on moist to wet calcareous (calcium-rich, or alkaline) tallgrass prairies and sedge meadows (many flooded for 1 - 2 weeks per year). It most often grows in relatively undisturbed grassland, but can also be found in moderately disturbed sites such as roadside ditches. (NatureServe, 2015). The persistence of western prairie fringed orchid is dependent on periodic disturbance by fire, mowing, or grazing (USFWS, 2016). Flooding decreases survival of all affected western prairie fringed orchid plants (Sieg and Wolken 1999). Western prairie fringed orchid may preferentially associate with *Ceratorhiza* species (Sharma et al. 2003a), which “appear to be the dominant orchid mycobionts in

Midwestern prairies” (Sharma 2002) (USFWS, 2009). Habitat conditions vary across the geographic range of the orchid. Populations in northwestern Minnesota may occur in areas where standing water is present, whereas a few populations in southern Minnesota are found on shallow soils over bedrock where standing water is not present in the spring (Biederman et al. 2014, p. 106). The location of western prairie fringed orchids at extant sites may be influenced by depth to groundwater. Knudson (2014) found that annual fluctuations in groundwater depth may influence the amount of moisture available to orchids and result in spatial shifts of orchid populations on the landscape (p. 71). (USFWS, 2021)

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Seeds are wind-dispersed and may also be adapted for dissemination through the soil profile by water (USFWS, 2016).

Population Information and Trends

Population Trends:

Unknown. Inferred from information (USFWS, 2021)

Species Trends:

Unknown. Inferred from information (USFWS, 2021)

Resiliency:

Resiliency describes the ability of populations to withstand stochastic events, arising from random factors. Due to the wide distribution of the orchid, it is not likely that a range-wide environmental or stochastic event would affect all the extant populations on the landscape. Stochastic events (e.g., extreme drought or agricultural practices) could impact individual populations. Habitat quality has been reduced over time due to land conversion, hydrologic changes, and encroaching dominant vegetation (native plants and non-native, invasive plant species). (USFWS, 2021).

Representation:

Representation influences the ability of a species to adapt to changing environmental conditions over time. Representation refers to the breadth of genetic diversity within a species; however, environmental diversity may be used as a surrogate for genetic diversity. Orchid populations are currently found in eight ecoregions (Fig. 1) that represent a range of ecological settings. Recent genetic research on the orchid suggests that the species may be vulnerable to inbreeding depression in the future (Ross and Travers 2016; Travers et al. 2017). Northern populations sampled by Ross and Travers (2016) exhibited moderate genetic diversity. Overall, the species occupies numerous ecoregions but genetic diversity across ecoregions is unknown. Additionally, as described above, the recovery criteria outlined in the recovery plan have not been met. Three out of nine ecoregions have occupied habitat protected at protection levels 4 through 9 (The Nature Conservancy 1996) that harbor 90% or more of the total plants in each ecoregion. Additionally, no sites are managed in accordance with Service-approved management plans or guidelines. Orchid populations are also exhibiting stable (relative to the previous review), declining, or undeterminable population trends as a result of hydrologic changes and the expansion of non-native, invasive plant species. (USFWS, 2021).

Redundancy:

Redundancy influences the ability of a species to survive catastrophic events and is often assessed in terms of the number of populations of a species and distribution of those populations across the landscape. Historically, western prairie fringed orchid was found in nine states. Currently, there are 299 extant western prairie fringed orchid populations across 6 states. Twenty-nine new orchid sites have been documented since the last review and nineteen sites are now considered extirpated. Six of the eight ecoregions with extant orchid sites contain more than ten populations except for the Minnesota and Northeast Iowa Morainal-Oak Savannah (222M) and Central Dissected Till Plains (251C) ecoregions. The Minnesota and Northeast Iowa Morainal-Oak Savannah ecoregion contains 6 populations spread across 130 miles (209 km) and the Central Dissected Till Plains ecoregion contains 1 population. The orchid sites in these ecoregions are separated by at least 168 miles (270 km). The populations in these ecoregions are at a higher risk from a catastrophic event (e.g., a multi-year ecoregion-wide drought) (USFWS, 2021).

Number of Populations:

172 (NatureServe, 2015)

Population Size:

~15,000 (inferred from NatureServe, 2015)

Population Narrative:

Platanthera praeclara has experienced over a 60% decline according to county records (Harrison, 1989). It is known from 172 extant occurrences. There are four large populations with 1000+ individuals each. All populations in the southern half of the range are small. The three largest known, extant populations are found in the northern half of the range and occur near Vita, Manitoba (3000 - 5000 plants), Pembina Trail Preserve in Minnesota (several thousand plants), and Sheyenne National Grassland, North Dakota (approximately 3000 plants) (NatureServe, 2015). Additionally, as described above, the recovery criteria outlined in the recovery plan have not been met. Three out of nine ecoregions have occupied habitat protected at protection levels 4 through 9 (The Nature Conservancy 1996) that harbor 90% or more of the total plants in each ecoregion. Additionally, no sites are managed in accordance with Service-approved management plans or guidelines. Orchid populations are also exhibiting stable (relative to the previous review), declining, or undeterminable population trends as a result of hydrologic changes and the expansion of non-native, invasive plant species. (USFWS, 2021)

Threats and Stressors

Stressor: Nonnative species (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Inter-seeding of non-native species, especially Garrison creeping foxtail (a cultivated variety of *Alopecurus arundinaceus* Poir), into wet prairie or wet meadows to increase livestock forage is now promoted in Nebraska (G. Steinauer, pers. comm., 2005; Volesky et al. 2003). This grass may pose a previously unrecognized threat if it is introduced into sites inhabited by western prairie fringed orchid (G. Steinauer, pers., comm. 2005). Exotic, cool season grasses also are

invading and increasing in western prairie fringed orchid habitats in Nebraska – a long-term trend that may be exacerbated by annual mid-summer haying (G. Steinauer, pers. comm., 2005) (USFWS, 2009). Invasive, non-native plant species continue to spread at western prairie fringed orchid locations throughout the species' geographic range. Although the Service has not compiled a complete list of threats to western prairie fringed orchids for each site, invasive plant species are noted as a current threat to at least 32% of extant sites. The previous review noted approximately 20% of extant sites had invasive species present with leafy spurge and reed canary grass (*Phalaris arundinacea*) the two most frequently reported threats (USFWS 2009). Smooth brome (*Bromus inermis* Leyss.), an invasive grass species becoming increasingly common in northern tall grass prairies, threatens orchid sites in southern Minnesota (Biederman et al. 2014, p. 105). Queen Anne's lace (*Daucus carota*) and wild parsnip (*Pastinaca sativa*) have been observed in or adjacent to western prairie fringed orchid populations in Minnesota (Anderson, Minnesota Biological Survey, January 21, 2021, pers. comm.). Invasive species documented at sites in Nebraska include leafy spurge, reed canary grass, and yellow bedstraw (*Galium verum*), which is currently present at one site but expected to invade other orchid sites in the future (Steinauer 2013). Invasive and hybrid cattail (*Typha* spp.) threaten western prairie fringed orchid sites on the Shewen National Grassland (Swenson, Shewen National Grasslands, February 19, 2021, pers. comm.). Reed canary grass continues to spread at extant orchid sites and reduces the amount of suitable habitat available for orchids. The previous review identified Garrison creeping foxtail (*Alopecurus arundinaceus*) as a non-native, invasive species posing a threat to orchid populations on and near Valentine National Wildlife Refuge in Nebraska (USFWS 2009). The foxtail does not appear to be spreading aggressively and is currently contained to one unit. Reed canary grass poses a larger threat, in addition to encroaching native woody vegetation (Nenneman, Valentine National Wildlife Refuge, December 16, 2020, pers. comm.) (USFWS, 2021)

Stressor: Herbivory (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Although herbivore impacts may be significant locally in some years (Borkowsky 2006:62), it is not clear whether native herbivores threaten any populations. The recovery plan (p. 13) mentions several herbivores that have fed on western prairie fringed orchids. Since completion of the recovery plan, at least one additional taxon, rose chaffer beetles (assumed to be *Macrodactylus subspinosus*, Scarabaeidae), was found feeding on western prairie fringed orchid. Rose chaffer beetles fed on a significant number of western prairie fringed orchid plants in Nebraska's Pierce and Madison counties in 2002 and the affected plants later exhibited fungal infections. Levels of this herbivory decreased after 2002, but persisted at least until 2005 (Gerry Steinauer, Nebraska Game and Parks Commission, pers. comm., 2005). Watson (2001b) found predated seed capsules that contained unidentified insect pupae at Kalsow Prairie in Iowa in 2001 (USFWS, 2009).

Stressor: Land use activities (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: In its recovery plan (U.S. Fish and Wildlife Service 1996) the Service mostly reiterated the threats it described in the final listing rule, but emphasized that conversion of habitat to

cropland was the greatest remaining threat to southern populations. It also emphasized that little was known about how to ensure that burning, grazing, and mowing are conducted in a manner not adverse to western prairie fringed orchid populations and pointed out that actions that directly or indirectly lower water levels in the rooting zone of plants “have the potential of serious adverse impacts.” In addition, it implied that potential impacts of pesticides to western prairie fringed orchid and its pollinators were also a threat (U.S. Fish and Wildlife Service 1996:17) (USFWS, 2009). Since the previous 5-year review, researchers have examined the impact of management actions on western prairie fringed orchids. The spread of invasive, non-native species and encroaching woody vegetation at orchid sites requires management that could negatively impact western prairie fringed orchids if conducted during active growth periods. Management actions at known orchid sites include prescribed burns, mowing or haying, and cattle grazing (Alexander et al. 2010b, Biederman et al. 2014, Bleho et al. 2015, Morrison et al. 2015). Periodic burns conducted every two or three years may benefit western prairie fringed orchids (Bleho et al. 2015, p. 191). Prescribed burns conducted during the spring (e.g., early May) or prior to the growing degree day threshold of 199 days would minimize direct negative impacts to the orchid (Morrison et al. 2015, p. 253; Biederman et al. 2018, p. 6). Fire to manage invasive plant species could also occur in the fall, when western prairie fringed orchid plants are not in the rapid growth stage and invasive plant species (e.g., smooth brome) can still be effectively targeted (Biederman et al. 2014, p. 107). Fall burns should occur in October or November to avoid negatively impacting seed pod maturation and or seed dispersal that occurs in mid-late September (Alexander et al. 2010a, p. 59; Morrison et al. 2015, p. 253). Cattle grazing and mowing may negatively impact western prairie fringed orchids (Alexander et al. 2010a,b, Bleho et al. 2015). Alexander et al. (2010b) noted that cattle grazing may negatively impact orchid height, ability to survive to seed capsule maturity, and carbohydrate storage (p. 47-48). In their study, individual orchids that survived to seed capsule maturity produced 20% fewer seed capsules than individuals in un-grazed pastures (Alexander et al. 2010b, p. 47). Grazing may reduce carbohydrate stores individual plants require to overwinter (Alexander et al. 2010b, p. 48). By deferring mowing and grazing actions until after mid-September, orchid embryos may reach full size and seeds may be dispersed (Alexander et al. 2010a, p. 59). (USFWS, 2021)

Stressor: Collection (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Watson (2001b) reported that trails made by humans wound through Sheeder Prairie in Iowa and seemed to ‘converge on areas where flowering orchids were located’ and coincided with observations of missing flowers (USFWS, 2009).

Stressor: Herbicides and Insecticides (USFWS, 2021)

Exposure:

Response:

Consequence:

Narrative: The Nebraska Natural Heritage Inventory identified four major threats to orchid populations, 1) conversion of suitable habitat to cropland, 2) other land use or land management changes, 3) inappropriate application of herbicides and insecticides, and 4) non-native, invasive species encroachment (Steinauer 2013; Stansberry, U.S. Fish and Wildlife Service, February 19, 2021, pers. comm.). Seed capsule formation or production in western prairie fringed orchids may be linked to several factors including habitat quality, herbivory, wind speed, and the abundance

of sphinx moths in the areas surrounding orchid populations. Habitat fragmentation and herbicide or pesticide use may reduce the amount of suitable habitat for sphinx moth pollinators (Borkowsky and Westwood 2009, p. 111). A decline in sphinx moth pollinators may ultimately lead to a decrease in orchid seed capsule production. (USFWS, 2021)

Recovery

Reclassification Criteria:

Not applicable.

Delisting Criteria:

1. Sites that include occupied habitat harboring 90 percent of plants in each ecoregion are protected at protection codes 4 through 9 (public ownership or higher level of protection), and managed in accordance with a Service-approved management plan or guidelines (USFWS, 1996).
2. This plan must assure implementation of management practices that provide the range and spatial distribution of successional and hydrologic regimes required to maintain the species and its pollinators in self-sustaining, naturally occurring populations, and must remain in effect following delisting (USFWS, 1996).

Recovery Actions:

- Maintain habitat of known populations as native prairie (USFWS, 1996).
- Provide the highest level of state legal protection appropriate for all populations (USFWS, 1996).
- Develop and implement habitat management plans that sustain and enhance *P. praeclara* populations (USFWS, 1996).
- Conduct appropriate research and monitoring (USFWS, 1996).
- Identify and search potential habitat (USFWS, 1996).
- Disseminate information about the species to a variety of audiences (USFWS, 1996).
- Revise the recovery criteria to include clear and measurable standards to determine whether western prairie fringed orchid plants are part of a viable population. The recovery criteria require that plants be under protective ownership or control and appropriately managed to count towards recovery in each ecoregion. There are no standards within the criteria, however, to assess whether these plants are part of populations that are viable. Although not addressed by the recovery criteria, actions 42 (Determine parameters required to maintain viable self-sustaining populations) and 424 (Conduct a population viability analysis for the species) do address this issue and a preliminary population viability analysis has been completed based on demographic monitoring (USFWS, 2009).
- Ensure that any revised recovery criteria are objective and measurable and address the following threats, as appropriate: Drainage and other actions that directly or indirectly lower water levels in the rooting zone of plants; Isolation and low reproduction of small populations; Herbicide and pesticide impacts to western prairie fringed orchid and its pollinators; Collection of plants from small populations; Effects of invading exotic species and actions to control those species; Inter-seeding of non-native species into wet prairie in Nebraska, especially creeping foxtail (*Alopecurus arundinaceus* Poir, also called Garrison creeping foxtail) (USFWS, 2009).

- Describe a process by which the Service will evaluate management plans for the purposes of measuring progress towards recovery. This should include a description of the Service's review process (e.g., who will conduct and approve these reviews for the Service) and the basis for evaluating the adequacy of each plan (USFWS, 2009).
- Compile existing management plans for sites where western prairie fringed orchid is extant and protected from conversion and determine whether they are adequate to ensure the conservation of the respective western prairie fringed orchid populations (USFWS, 2009).
- Implement recovery action 33 – Develop or maintain appropriate mowing regimes (U.S. Fish and Wildlife Service 1996:20). Steinauer (2000:4) briefly summarized the importance of the Nebraska's eastern Sandhills region for the conservation of western prairie fringed orchid and suggested that significant progress towards the species' conservation could be made by modifying haying practices at some sites (USFWS, 2009).
- Conduct additional surveys in the Nebraska Sandhills when soil moisture levels may be suitable for significant levels of flowering. Additional surveys in this region may identify additional populations of western prairie fringed orchid (Steinauer 2000:4), but significant surveys have not been conducted since 2000 (recovery action 52 – Identify and search potential new sites [U.S. Fish and Wildlife Service 1996:22]) (USFWS, 2009).
- Improve tracking of invasive species threats for each site, in cooperation with the states and others, to determine the relative range-wide harm of each invasive species. Invasive species should be identified as a threat at a site if they are present and if current or anticipated management is unlikely to be sufficient to control invasives to the extent that the invasive(s) will no longer pose a threat to western prairie fringed orchid (USFWS, 2009).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: The Service provides the following recommendations:
 - Revise the recovery plan to include clear and measurable standards to determine whether western prairie fringed orchid populations are viable and to address current threats to the continued existence of the western prairie fringed orchid. See the previous 5-year review for a list of threats to include (USFWS 2009).
 - Coordinate survey efforts across the geographic range of the species (e.g., compile existing survey protocols) and assess the status of populations that have not been monitored for over 25 years (1995 or earlier).
 - Expand survey efforts in the Red River Valley (251A) and the Lake Agassiz-Aspen Parklands (222N) ecoregions to search for new or undocumented western prairie fringed orchid sites.
 - Examine western prairie fringed orchid responses to management activities and develop a best management practices fact sheet with species experts for land managers and project proponents across the orchid's geographic range.
 - Increase the percentage of protected sites in ecoregions where the protection criterion has not been met. This may include implementing and/or increasing outreach efforts with private landowners.
 - Describe a process by which the Service would approve management plans for the purpose of measuring progress towards recovery, which should include a description of the Service's review process (e.g., who would conduct and approve these reviews for the Service) and the basis for evaluating the adequacy of each plan.
 - Compile existing management plans for sites where western prairie fringed orchid is extant and protected from conversion and determine whether they are adequate to ensure the conservation of the respective western prairie fringed orchid populations.
 - Manage habitat to support western prairie fringed orchids through practices that duplicate the natural processes of the tallgrass prairie ecosystem (e.g., prescribed burns, control of non-native invasive species and/or encroaching woody vegetation).
 - Encourage and support research focused on western prairie fringed orchid pollinators. This may include research examining hawkmoth distribution, population

levels, management needs, or reproduction (USFWS, 2021).

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed July 2016

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

USFWS 2009. Western Prairie Fringed Orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Twin Cities Field Office Bloomington, Minnesota

U.S. Fish and Wildlife Service. 1996. *Platanthera praeclara* (western prairie fringed orchid) recovery plan. U.S. Fish and Wildlife Service, Ft. Snelling, Minnesota. vi + 101 pp. USFWS. 2021. Western prairie fringed orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region Minnesota-Wisconsin Ecological Services Field Office Bloomington, Minnesota. 20 pp.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.” USFWS. 2021. Western prairie fringed orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region Minnesota-Wisconsin Ecological Services Field Office Bloomington, Minnesota. 20 pp.

USFWS. 2009. Western Prairie Fringed Orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Twin Cities Field Office Bloomington, Minnesota. USFWS. 2021. Western prairie fringed orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region Minnesota-Wisconsin Ecological Services Field Office Bloomington, Minnesota. 20 pp.

USFWS. 2009. Western Prairie Fringed Orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Twin Cities Field Office Bloomington, Minnesota.

USFWS. 2021. Western prairie fringed orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region Minnesota-Wisconsin Ecological Services Field Office Bloomington, Minnesota. 20 pp.

USFWS. 1996. *Platanthera praeclara* (Western Prairie Fringed Orchid) Recovery Plan. U.S. Fish and Wildlife Service, Ft. Snelling, Minnesota. vi + 101 pp. https://ecos.fws.gov/docs/recovery_plan/960930a.pdf

USFWS 2009. Western Prairie Fringed Orchid (*Platanthera praeclara*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Twin Cities Field Office, Bloomington, Minnesota.

SPECIES ACCOUNT: *Pleomele forbesii* (Hala pepe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 9/18/2012; Pacific Region (R1) (USFWS, 2016)

Physical Description

A tree, 3-7 m tall, usually with few branches. Leaves are borne at the branch tips, 24-37 cm long, with narrow panicles, approximately 15-35 cm long. The flowers are greenish yellow (NatureServe, 2015).

Taxonomy

in the asparagus (Asparagaceae) family (USFWS, 2012)

Historical Range

On the island of Oahu in the state of Hawaii, in the Waianae Mountains (USFWS, 2012).

Current Range

On the island of Oahu in the state of Hawaii, in the Waianae Mountains and the Koolau Mountains (USFWS, 2012).

Critical Habitat Designated

Yes; 9/18/2012.

Legal Description

On September 18, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Pleomele forbesii* (Hala pepe) under the Endangered Species Act of 1973, as amended (Act) (77 FR 57648-57862). The critical habitat designation includes 17 critical habitat units, which encompass approximately 9,747 acres on the Island of Oahu, Hawaii.

The critical habitat designation for *Pleomele forbesii* includes areas that were determined by the Service to be occupied at the time of listing, and also includes unoccupied suitable habitat that is essential to the conservation of this species by providing the PCEs necessary for reintroductions and expansion of the existing wild populations within their historical range.

Critical Habitat Designation

The critical habitat designation for *Pleomele forbesii* includes 17 critical habitat units, covering three ecosystem types, which encompass approximately 9,747 acres on the Island of Oahu, Hawaii (77 FR 57648-57862). The designated critical habitats include: Oahu—Lowland Dry—Units 1, 2; Oahu—Lowland Mesic—Units 1, 2, 3, 4, 5, 6, 7; , Oahu—Dry Cliff—Units 1, 2, 3, 4, 6, 7a, 7b, 8.

Oahu—Lowland Dry—Unit 1 [102 ac (41 ha)]; This area consists of 49 ac (20 ha) of State land and 53 ac (22 ha) of privately owned land in the Waianae Mountains, extending from Haili Gulch to Kawaipahai. Oahu—Lowland Dry— Unit 2 [29 ac (12 ha)]. This area consists of 29 ac (12 ha) in the lowland dry ecosystem in the Waianae Mountains, on Federal land within Kaena Point State Park.

Oahu—Lowland Mesic—Unit 1 [4,448 ac (1,800 ha)]. This area consists of 3,565 ac (1,443 ha) of State land, 583 ac (236 ha) of City and County of Honolulu land, 22 ac (9 ha) of Federal land, and

277 ac (112 ha) of privately owned land in the lowland mesic ecosystem in the Waianae Mountains, encompassing a large area including the north slopes of Mt. Kaala, from the Pahole NAR to the Kaala NAR, and south to the Waianae Kai Forest Reserve (FR). Oahu—Lowland Mesic—Unit 2 [1,063 ac (430 ha)]. This area consists of 1,063 ac (430 ha) in the lowland mesic ecosystem on the windward side of the Waianae Mountains, from Puuhapapa south to Puukaua. Oahu—Lowland Mesic—Unit 3 [353 ac (143 ha)]. This area consists of 353 ac (143 ha) in the lowland mesic ecosystem on the windward side of the Waianae Mountains, from Pohakea Pass to Kaiakuakai Gulch. Oahu—Lowland Mesic—Unit 4 [20 ac (8 ha)]. This area consists of 20 ac (8 ha) in the lowland mesic ecosystem on the windward side of the Koolau Mountains, between the Waipilopilo and Hanaimoa gulches, on State-owned land within the Hauula Forest Reserve. Oahu—Lowland Mesic—Unit 5 [29 ac (12 ha)]. This area consists of 29 ac (12 ha) in the lowland mesic ecosystem on the windward side of the Koolau Mountains, in Maakua Gulch and ridge; is State-owned; and within the Hauula FR. Oahu—Lowland Mesic—Unit 6 [247 ac (100 ha)]. This area consists of 12 ac (5 ha) State land and 235 ac (95 ha) of privately owned land in the lowland mesic ecosystem on the windward side of the Koolau Mountains, inland of Kaaawa Point, and is partially within Ahupuaa O Kahana State Park. Oahu—Lowland Mesic—Unit 7 [1,669 ac (676 ha)]. This area consists of 681 ac (276 ha) of State land, 129 ac (52 ha) of City and County of Honolulu land, and 852 ac (345 ha) of privately-owned land in the lowland mesic ecosystem on the leeward side of the Koolau Mountains, on Waialae Nui ridge.

Oahu—Dry Cliff—Unit 1 [49 ac (20 ha)]. This area consists of 49 ac (20 ha) in the dry cliff ecosystem, on the leeward side of the Waianae Mountains, along the rim of Makua Valley. Oahu—Dry Cliff—Unit 2 [412 ac (167 ha)]. This area consists of 320 ac (130 ha) of State land and 91 ac (37 ha) of City and County of Honolulu land in the dry cliff ecosystem, on the leeward side of the Waianae Mountains, along the ridge from Keaau to Ohikilolo. Oahu—Dry Cliff—Unit 3 [450 ac (182 ha)]. This area consists of 349 ac (141 ha) of City and County of Honolulu land and 101 ac (41 ha) of State land in the dry cliff ecosystem on the leeward side of the Waianae Mountains, along the eastern rim of Makaha Valley along Kamaileunu Ridge. Oahu—Dry Cliff—Unit 4 [24 ac (10 ha)]. This area consists of 24 ac (10 ha) of State land in the dry cliff ecosystem on the leeward side of the Waianae Mountains, along Kauaopuu ridge, which divides Waianae Kai and Lualualei valleys. Oahu—Dry Cliff—Unit 6 [149 ac (60 ha)]. This area consists of 149 ac (60 ha) in the dry cliff ecosystem on the leeward side of the Waianae Mountains, on State land along the rim of Lualualei Valley from Puukanehoa to Puukaua. Oahu—Dry Cliff—Unit 7a [68 ac (27 ha)]. This area consists of 68 ac (27 ha) of State land in the dry cliff ecosystem on the leeward side of the Waianae Mountains, along the rim of Lualualei Valley to Pohakea. Oahu—Dry Cliff—Unit 7b [38 ac (16 ha)]. This area consists of 38 ac (16 ha) of State land in the dry cliff ecosystem on the leeward side of the Waianae Mountains, along the rim of Lualualei Valley at Palikea. Oahu—Dry Cliff—Unit 8 [259 ac (105 ha)]. This area consists of 259 ac (105 ha) in the dry cliff ecosystem on the leeward side of the Waianae Mountains, on State land along the rim of Nanakuli Valley from Palehua to Puumanawanua, and partially within the Nanakuli Forest Reserve.

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 *Pleomele forbesii* critical habitat consists of the following components according to ecosystem type (77 FR 57648-57862). Note: *Pleomele forbesii* occurs within the Lowland dry, Lowland mesic and Dry cliff ecosystems in the Waianae Mountain caldera complex and from the Lowland mesic ecosystem in the Koolau Mountain caldera complex:

Oahu—Lowland Dry—Units 1, 2. (A) Elevation: <3,300 ft (<1,000 m). (B) Annual Precipitation: <50 in (<130 cm). (C) Substrate: Weathered silty loams to stony clay, rocky ledges, little weathered lava. (D) Canopy: Diospyros, Myoporum, Pleomele, Santalum, Sapindes. (E) Subcanopy: Chamaesyce, Dodonaea, Leptecophylla, Osteomeles, Psydrax, Scaevola, Wikstroemia. (F) Understory: Alyxia, Artemisia, Bidens, Chenopodium, Nephrolepis, Peperomia, Plumbago, Sicyos, Sida, Waltheria.

Oahu—Lowland Mesic—Units 1, 2, 3, 4, 5, 6, 7. (A) Elevation: <3,300 ft (<914 m). (B) Annual Precipitation: 50–75 in (130–190 cm). (C) Substrate: Shallow soils, little to no herbaceous layer. (D) Canopy: Acacia, Diospyros, Metrosideros, Myrsine, Pouteria, Santalum. (E) Subcanopy: Dodonaea, Freycinetia, Leptecophylla, Melanthera, Osteomeles, Pleomele, Psydrax. (F) Understory: Carex, Dicranopteris, Diplazium, Elaphoglossum, Peperomia.

Oahu—Dry Cliff—Units 1, 2, 3, 4, 6, 7a, 7b, 8. (A) Elevation: unrestricted. (B) Annual Precipitation: < 75 in (<190 cm). (C) Substrate: >65 degree slope, rocky talus. (D) Canopy: None. (E) Subcanopy: Antidesma, Chamaesyce, Diospyros, Dodonaea. (F) Understory: Bidens, Eragrostis, Melanthera, Schiedea.

Special Management Considerations or Protections

Special management considerations or protections are necessary throughout the critical habitat areas designated for *Pleomele forbesii* 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 feral ungulates, competition with nonnative species, hurricanes, landslides, rockfalls, flooding, fire, drought, and climate change. The reduction of these threats will require the implementation of special management actions within each of the critical habitat areas identified for this species.

Life History

Food/Nutrient Resources

Habitat Type

Adult: Terrestrial (USFWS, 2012)

Habitat Vegetation or Surface Water Classification

Adult: Mesic and dry forest and shrubland in the lowland dry, lowland mesic, and dry cliff ecosystem (USFWS, 2012)

Geographic or Habitat Restraints or Barriers

Adult: Elevations between 800 and 2,900 ft (USFWS, 2012)

Habitat Narrative

Adult: This species occurs in mesic and dry forest and shrubland in the lowland dry, lowland mesic, and dry cliff ecosystems in the Waianae and Koolau Mountains, at elevations between 800 and 2,900 ft (240 and 900 m) (USFWS, 2012).

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Unknown (NatureServe, 2015)

Species Trends:

Decline of 10-30% (NatureServe, 2015)

Population Growth Rate:

Unknown (NatureServe, 2015)

Number of Populations:

20 (USFWS, 2012)

Population Size:

<150 (USFWS, 2019)

Population Narrative:

On Oahu, there are approximately 19 occurrences totaling 290 to 307 individuals, from Keawaula, Kaluakauila, Kuaokala, Kahanahaiki, the east and south rim of Makua Valley, the rim of Waianae Kai Valley, Keaau, Makaha, Kamaileunu, Kolekole Pass, Puu Hapapa, Puukaua, Ekahanui, Halona, Palawai, and Nanakuli, in the Waianae Mountains, and one occurrence of a few individuals in the Koolau Mountains (USFWS, 2012). Long-term trend is unknown, and short-term trend is decline of 10-30% (NatureServe, 2015). Numbers of *Chrysodracon forbesii* are reported to be fewer than 150, and is a decline in total population size since the time of listing. A landscape-based assessment of climate change vulnerability for native plants of Hawai'i using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *C. forbesii* is highly vulnerable to the effects of climate change. Only a few propagules are in storage, and research is being conducted on cryopreservation techniques for long-term germplasm storage. (USFWS, 2019)

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Adverse impacts on habitat of this species have been identified from nonnative plants, animals (pigs and goats), fire, and climate change. The effects of nonnative plants on native plant species include competition and displacement; competition may be for water, light, or nutrients, or it may involve allelopathy (chemical inhibition of other plants). 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. The projected effects of climate change will likely exacerbate the effects of the other threats to the species (USFWS, 2012).

Stressor: Predation and herbivory (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Predation and herbivory by nonnative animal species (pigs and goats) is considered an ongoing threat to *Pleomele forbesii* throughout the species range. Non-native animals cause mechanical damage to plants and destruction of plant parts (branches, fruits, and seeds) (USFWS, 2012).

Stressor: Lack of regeneration (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Lack of regeneration or low levels of regeneration (i.e., reproduction) in the wild has been documented, and represents a threat to, *Pleomele forbesii*. There are 19 populations of *P. forbesii* in the Waianae Mountains, and only one population in the Koolau Mountains. The Koolau population is at risk of extirpation because of very few (if any) seedlings or juvenile plants have been observed, which indicates a lack of reproduction. (USFWS, 2012).

Stressor:

Exposure:

Response:

Consequence:

Narrative:

Stressor:

Exposure:

Response:

Consequence:

Narrative:

Stressor:

Exposure:

Response:

Consequence:

Narrative:

Stressor:

Exposure:

Response:

Consequence:

Narrative:

Recovery

Reclassification Criteria:

Not available.

Delisting Criteria:

Not available.

Recovery Actions:

- Not available.

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** • Surveys and inventories—Survey for *Chrysodracon forbesii* in historical locations and potentially suitable habitat. Monitor all known occurrences. • Ungulate monitoring and control—Continue to construct and maintain fenced exclosures to protect individuals from the negative impacts of feral ungulates. • Invasive plant monitoring and control—Continue to control established ecosystem-altering nonnative invasive plant species around all populations. • Insect predation or herbivory—Develop and implement control methods for the two-spotted leafhopper. • Captive propagation for genetic storage and reintroduction—Increase collection of seeds for storage and propagation efforts for maintenance of genetic stock. • Reintroduction and translocation—Reintroduce individuals to suitable habitat within historic range that is being managed for known threats to this species to build resiliency and redundancy and promote regeneration at populations. • Climate change adaptation strategy—Research the suitability of habitat in the future due to the impacts of climate change • Alliance and partnership development—Contribute to implementation of ecosystem-level restoration and management to benefit this taxon. • Update the listed entity on 50 CFR 17 to match the currently recognized taxonomy and change of plant family classification. (USFWS, 2019)
- **Current Management Actions:** • Ungulate management and control—Approximately 100 individuals of *Chrysodracon forbesii* occur within seven of the Army Natural Resources Program's (ANRP) management units for other listed species in the Wai'anāe mountains and could benefit from fencing for exclusion of feral ungulates and nonnative plant management (U.S. Army Garrison 2010; ANRP 2018). • Captive propagation for genetic storage and reintroduction—
 - o Propagules from five individuals from Mākua are in micropropagation to provide material for research on cryopreservation storage techniques for this species (Lyon Arboretum 2018, in litt.).
 - o Waimea Arboretum reported propagation and storage of one individual in 2013, but no plants since then have been in their collection (Waimea Arboretum 2013, in litt., 2018, in litt.). (USFWS, 2019)

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

U.S. Fish and Wildlife Service. 2012. Endangered Status for 23 Species on Oahu and Designation of Critical Habitat for 124 Species

Final Rule. 77 Federal Register 181. September 18, 2012. Pages 57648-57862.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Endangered Status for 23 Species on Oahu and Designation of Critical Habitat for 124 Species. Final Rule. 77 FR 57648-57862 (September 18, 2012)

Final Rule. 77 Federal Register 181. September 18, 2012. Pages 57648-57862

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Accessed September, 2016. USFWS. 2019. Pleomele forbesii (hala pepe) 5-Year Review Summary and Evaluation U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 19 pp.

USFWS. 2012. Endangered Status for 23 Species on Oahu and Designation of Critical Habitat for 124 Species

Final Rule. 77 Federal Register 181, September 18, 2012. Pages 57648 - 57862.

USFWS. 2019. Pleomele forbesii (hala pepe) 5-Year Review Summary and Evaluation U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 19 pp.

SPECIES ACCOUNT: *Pleomele hawaiiensis* (Hala pepe)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/10/1996; Pacific Region (R1) (USFWS, 2016)

Physical Description

A branching tree, 5 to 6 meters (16 to 20 feet) tall, with leaves spirally clustered at the tips of branches, leaving large brown leaf scars as they fall off. The leaves measure 23 to 38 centimeters (9 to 15 inches) long and 1.4 to 2.7 centimeters (0.6 to 1 inch) wide. Flowers are numerous in terminal clusters with a main stalk 6 to 13 centimeters (2 to 5 inches) long and individual flower stalks 5 to 12 millimeters (0.2 to 0.5 inch) long. The three sepals and three petals of the flower are similar and pale yellow, 33 to 43 millimeters (1.3 to 1.7 inches) long, with a constricted base. The fruit is a red berry about 10 to 13 millimeters (0.4 to 0.5 inch) long. This species differs from other Hawaiian species in this genus by its pale yellow flowers, the size of the flowers, the length of the constricted base of the flower, and the width of the leaves (USFWS, 1998).

Taxonomy

The genus is found in old world tropics, this species is endemic to the island of Hawaii (NatureServe, 2015). The genus has been included in the Agavaceae family (Wagner et al. 1999), broadly-defined within the Liliaceae family (USFWS 2003), or under the Asparagaceae or Dracaenaceae family (Mabberley 2008). *Pleomele* is sometimes considered by others to be a part of an expanded concept of the genus *Dracaena* (Mabberley 2008), although this taxonomic interpretation has not been followed in Hawaii (Wagner et al. 1999) (USFWS, 2012).

Historical Range

Pleomele hawaiiensis originally occurred from the Kohala Mountains to Kau on Hawaii Island (USFWS 1998) (USFWS, 2012).

Current Range

It is known from Naulu Forest Areas I and II and Poliokeawe Pali (Abbott and Pratt 1996) and reported from the lowland dry forest at Puuwaawaa (Giffin 2009) (Hawaii). When critical habitat was designated, *P. hawaiiensis* was known from Kiholo, Manuka Natural Area Reserve System, and Hawaii Volcanoes National Park (USFWS 2003) (USFWS, 2012).

Critical Habitat Designated

Yes; 7/2/2003.

Legal Description

On July 2, 2003, the U.S. Fish and Wildlife Service (Service), designated critical habitat pursuant to the Endangered Species Act of 1973, as amended (Act), for *Pleomele hawaiiensis* on the island of Hawaii (68 FR 39623 - 39722).

Critical Habitat Designation

The critical habitat designation for *Pleomele hawaiiensis* includes four units totaling 32,010 acres in Hawaii County, Hawaii. The units are Hawaii 7—*Pleomele hawaiiensis*—a, Hawaii 10—*Pleomele hawaiiensis*—b, Hawaii 18—*Pleomele hawaiiensis*—c, Hawaii 23—*Pleomele*

hawaiiensis—d. All of the units are currently occupied by individuals of this species. Each unit is essential to the conservation of *P. hawaiiensis* because it supports an extant colony of this species and includes habitat that is important for the expansion of the present population, which is currently considered nonviable. Each unit is geographically separated from other critical habitat for this island-endemic species within its historical range in order to reduce the likelihood of all recovery populations being destroyed by one naturally occurring catastrophic event. The four units designated for this species on the island of Hawaii provide habitat to support a total of nine populations, each with 100 mature, reproducing individuals. Kamehameha Schools land that we are excluding from this designation of critical habitat provides habitat for one additional population.

Hawaii 7—Pleomele hawaiiensis—a [677 ha (1,673 ac)]: This unit contains Kupenau summit and the ridges around Pololu Valley, and is in the Pololu watershed in the west and Honokane Nui watershed in the east. The west side of the unit is in the Kohala Forest Reserve. This unit provides habitat for 1 population of 100 individuals of *P. hawaiiensis* and is currently occupied by 21 to 31 individuals. This unit provides the northernmost critical habitat within the species' historical range.

Hawaii 10—Pleomele hawaiiensis—b [1,339 ha (3,306 ac)]: This unit contains no named natural features and is entirely in the Kiholo watershed. The unit provides habitat for 1 population of 100 individuals of *P. hawaiiensis* and is currently occupied by 50 to 100 individuals.

Hawaii 18—Pleomele hawaiiensis—c [1,997 ha (4,934)]: This unit contains no named natural features and is mostly in the Kauna watershed with a small portion on the southwest side in the Kiilae watershed. The unit is completely within Manuka NAR; provides habitat for 2 populations of 100 individuals of *P. hawaiiensis*; and is currently occupied by 5 individuals. This unit provides the southernmost critical habitat within the species' historical range.

Hawaii 23—Pleomele hawaiiensis—d [8,943 ha (22,097 ac)]: This unit contains the Hilina Pali, Holei Pali, Makahanu Pali, Poliokeawe Pali, Puueo Pali, the Keana Bihopa summit, and portions of Kipuka Kaena Bihopa, Kipuka Papalinamoku, and Kipuka Pepeiau. It is in the Kapala watershed in the west and the Kilauea watershed in the east and lies completely within HVNP. This unit provides habitat for 5 populations of 100 individuals of *P. hawaiiensis* and currently is occupied by 9 to 10 individuals. This unit provides the easternmost critical habitat within the species' historical range.

Primary Constituent Elements/Physical or Biological Features

Habitat features that are essential for this species include, but are not limited to, open aa lava in diverse lowland dry forests and *Metrosideros-Diospyros* lowland dry forest.

Special Management Considerations or Protections

The Service publishes this final rule acknowledging that they have incomplete information regarding many of the primary biological and physical requirements for this species. However, both the Act and the relevant court orders require the Service to proceed with designation at this time based on the best information available. As new information accrues, the Service may consider reevaluating the boundaries of areas that warrant critical habitat designation.

The following management actions are important in providing a conservation benefit to the species: feral ungulate control; wildfire management; nonnative plant control; rodent control; invertebrate pest control; maintenance of genetic material of the endangered and threatened plant species; propagation, reintroduction, and augmentation of existing populations into areas essential for the recovery of the species; ongoing management of the wild, outplanted, and augmented populations; maintenance of natural pollinators and pollinating systems, when known; habitat management and restoration in areas essential for the recovery of the species; monitoring of the wild, outplanted, and augmented populations; rare plant surveys; and control of human activities/access.

Life History**Food/Nutrient Resources****Reproductive Strategy**

Adult: Sexual (inferred from USFWS, 2012)

Lifespan

Adult: < 10 years (USFWS, 2012)

Breeding Season

Adult: February - June (USFWS, 2012)

Reproduction Narrative

Adult: It is a short-lived perennial (fewer than ten years). specimens held at the Bernice Pauahi Bishop Museum in February of 2011, the species flowering period is from February through June, and fruiting occurs from February through December (Bishop Museum 2011) (USFWS, 2012).

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Dry to mesic forest (USFWS, 2012)

Geographic or Habitat Restraints or Barriers

Adult: 281 - 2,925 ft. elevation (USFWS, 2012)

Habitat Narrative

Adult: Inhabits dry (or occasionally moist) forests on old lava flows (NatureServe, 2015). It now typically occurs in dry forest or occasionally in mesic forest between 86 and 892 meters (281 and 2,925 feet) elevation (USFWS, 2012).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Not available

Species Trends:

Declining (USFWS, 2012)

Number of Populations:

10 (USFWS, 2020)

Population Size:

300 - 400 wild (USWS, 2020)

Population Narrative:

As of 2009, there were 6 to 9 populations containing a total of 300 to 400 individuals (USFWS 2010). There are 479 outplanted individuals. Recent estimates of the population size of *P. hawaiiensis* suggest a gradual but sustained downward trend in the total number of individuals (J. Zimpfer, pers. comm. 2010) (USFWS, 2012). Approximately 350-400 wild individuals remain at 10 locations on the island of Hawai'i. A landscape-based assessment of climate change vulnerability for native plants of Hawai'i using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *Chrysodracon hawaiiensis* is vulnerable to the effects of climate change. Seed and cuttings collections from wild and reintroduced individuals, propagation, and reintroduction are ongoing. Approximately 1,000 individuals were reintroduced since the last 5-year review and some populations have a greater than 80% survival rate over two years. Reintroduced populations are provided protection from feral ungulates by fencing and ungulate control at Pu'uwa'awa'a and HVNP and recruitment of seedlings is observed at two populations. The overall impacts of rodent and insect predation is not known. (USFWS, 2020)

Threats and Stressors

Stressor: Habitat degradation (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Feral goats (*Capra hircus*), pigs (*Sus scrofa*), sheep (*Ovis aries*); invasive plants: *Lantana camara* (lantana), *Leucaena leucocephala* (koa haole), *Pennisetum setaceum* (fountain grass), *Schinus terebinthifolius* (Christmasberry); lava flow; residential and recreational development; fire (USFWS, 2012).

Stressor: Predation (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Cattle (USFWS 1996, 2002) and goats (Hawaii Department of Land and Natural Resources 2009). Weevils have been known to damage the seeds of this species (USFWS 1996, 2002). Insect damage to leaves at Naulu Forest Areas I and II and Poliokeawe Pali (Abbott and

Pratt 1996). Damage by rats (*Rattus* sp.) at Naulu Forest Areas I and II and Poliokeawe Pali (Abbott and Pratt 1996) (USFWS, 2012).

Stressor: Climate change (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Climate change may pose a threat to this species. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species (USFWS, 2012).

Recovery

Reclassification Criteria:

1. A total of five to seven populations should be documented on the Big Island (USFWS, 1998).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population (for short-lived perennials) (USFWS, 1998).
3. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered (USFWS, 1998).

Delisting Criteria:

1. A total of 8 to 10 populations of each taxon should be documented on the Big Island (USFWS, 1998).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population (for short-lived perennials) (USFWS, 1998).
3. Each population should persist at this level for a minimum of 5 consecutive years (USFWS, 1998).

Recovery Actions:

- Protect current populations and manage threats (USFWS, 1998).
- Conduct essential research (USFWS, 1998).
- Expand existing wild populations, as necessary (USFWS, 1998).
- Create new populations within historical range, as necessary (USFWS, 1998).
- Evaluate and validate recovery objectives (USFWS, 1998).
- Construct protective fencing around known populations and initiate removal of ungulates and alien plants (USFWS, 1998).
- Outplant new populations in areas of reduced threat (USFWS, 1998).
- Captive propagation for genetic storage and reintroduction: Collect cuttings or seed from tagged individuals, keeping close track of the maternal source for use in ex situ propagation. Continue to collect seeds from all existing populations and send to at least two or three different venues for propagation and storage. Increase the number of specimens available

- for reintroduction in ex situ stocks (USFWS, 2012).
- Reintroduction / translocation implementation – Continue to reintroduce the species back into its known historical range (USFWS, 2012).
 - Reintroduction / translocation site identification – While surveying for new populations or reintroduced populations, determine which sites are least invaded by invasive introduced plant species and which appear to have the highest likelihood of maintaining new reintroductions (USFWS, 2012).
 - Ecosystem-altering invasive plant species control – Continue to control ecosystem altering invasive plant species around all populations (USFWS, 2012).
 - Ungulate exclosures – Continue to construct ungulate-proof fenced exclosures around each population and monitor the fences for any signs of breaching (USFWS, 2012).
 - Ungulate control – Continue to control ungulates around all populations to provide protection against disturbances from feral ungulates (USFWS, 2012).
 - Competitive invasive plant species control – Control invasive introduced plant species around all populations that compete with the species (USFWS, 2012).
 - Predator / herbivore control – Implement effective control methods for rodents (USFWS, 2012).
 - Invertebrate control research: Conduct research on the damaging effects of weevils on the seeds of *Pleomele hawaiiensis* and if necessary, develop and implement effective measures to control weevils. Conduct research to identify the species that is causing leaf damage to the species at Hawaii Volcanoes National Park, if necessary develop and implement effective measures to control this insect (USFWS, 2012).
 - Site / area / habitat protection – Develop and implement effective measures to reduce the impact of agricultural and urban development and lava flows degradation of habitat (USFWS, 2012).
 - Surveys / inventories – Re-survey the known range of the species and other areas with suitable habitat for potentially undiscovered individuals or populations (USFWS, 2012).
 - Population biology research – Commence studies in the field to determine flower pollinators and fruit dispersers (USFWS, 2012).
 - Threat monitoring and control – Monitor the health of wild populations for evidence of insect damage and plant pathogens that might be reducing viability or contributing to senescence (USFWS, 2012).
 - Fire protection: Continue to maintain firebreaks around fenced exclosures at Puuwaawaa. Develop and implement fire management plans for all wild and reintroduced populations (USFWS, 2012).
 - Alliance and partnership development – Work with Hawaii Division of Forestry and Wildlife, National Park Service, and other land managers to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species (USFWS, 2012).
 - Threats research – Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species (USFWS, 2012).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: We are not aware of any new threats or significant new information regarding the species' biological status since the last 5-year review in 2012. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2020. • Surveys and inventories—Continue to conduct thorough surveys of all historical and suitable habitat

for new occurrences and to determine current status of known wild individuals of *Chrysodracon hawaiiensis*. • Ungulate monitoring and control—Continue to construct and maintain fenced enclosures to protect individuals from the negative impacts of habitat destruction and degradation, and browsing and trampling by ungulates. • Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species, and those that compete with *C. hawaiiensis* at all populations. • Agriculture and development protection—Develop and implement effective measures to reduce the impact of agricultural and urban development of habitat. • Lava flows protection—Select alternate reintroduction sites to reduce the possible impacts of lava flows. • Fire protection— o Continue to maintain fire breaks at Pu‘uwa‘awa‘a. o Implement fire management plans for HVNP and Pu‘uwa‘awa‘a and develop fire management plans for other wild and reintroduced populations of *C. hawaiiensis*. • Climate change adaptation strategy—Assess the modeled effects of climate change on this species and use to determine future landscape needed for the recovery of the species. • Predation and herbivore control— o Implement effective control methods for rodents. o Conduct research on the damaging effects of weevils on the seeds of *C. hawaiiensis* and if necessary, develop and implement effective control measures. o Identify the invertebrate species causing leaf damage at HVNP and, if necessary, develop and implement effective control measures. o Monitor wild and reintroduced populations for plant pathogens that may reduce viability or contribute to senescence. • Captive propagation for genetic storage and reintroduction— o Continue collection and propagation efforts for maintenance of genetic stock and for reintroduction. o Track maternal source of propagative materials for use in ex situ propagation. • Reintroduction and translocation—Determine optimal sites and continue to reintroduce individuals into areas that are being managed for known threats. • Population biology research—Study the reproductive biology of *C. hawaiiensis* to determine the pollinators and factors that aid in seed dispersal. • Federal Register updates—Update 50 CFR 17 to reflect the revised taxonomy. • Alliance and partnership development—Continue to work with the Hawai‘i Division of Forestry and Wildlife, Hawai‘i Volcanoes National Park, and other partners and land managers in planning and implementation of ecosystem-level restoration and management to benefit this species. (USFWS, 2020)

- New Management Actions: • Surveys and inventories— o The Department of Land and Natural Resources-Division of Forestry and Wildlife (DLNR-DOFAW) surveys for and monitors populations of *Chrysodracon hawaiiensis* in the North Kona Game management area (Pu‘uwa‘awa‘a) (DLNR-DOFAW 2017, draft, pp. 43–44, 57). o HVNP monitors reintroductions of *C. hawaiiensis* at six sites (Kealakomo and Nāulu, Kīpukapepeiao and Hilina Pali road, Ka‘aha, Kahuku-Kīpuka Māmane) (HVNP 2019, pp. 9–10). • Ungulate monitoring and control— o In 2013, 40 immature and two mature wild plants were found in Kahuku and cages were placed to protect the immature plants from trampling and herbivory by mouflon (HVNP 2019, p. 19). The DOFAW and Plant Extinction Prevention Program (PEPP) staff placed a temporary fence around the largest population (HVNP 2019, p. 19). Wild plants within the cages were recruiting seedlings in late 2017 (HVNP 2019, p. 19). Feral goats have been eliminated from hala pepe habitat in the older section of HVNP (National Park Service (NPS) 2015, p. 466). • Captive propagation for genetic storage and reintroduction— o Seeds of species in the genus *Chrysodracon* are short-lived or recalcitrant (desiccation-sensitive), preventing the seeds from being stored under conventional seed banking methods (Chau et al. 2019). o In 2013, the Volcano Rare Plant Facility (VRPF) reported propagation of 18 plants representing one individual at Kīpāhoehoe, nine plants representing two individuals at Kohala, 77 plants representing three individuals at Manukā, and 245 plants representing eight individuals at Pu‘uwa‘awa‘a. In 2014, one plant was propagated representing one individual at Kīpāhoehoe, three plants representing two individuals at Kohala, 41 plants representing two plant at Manukā, and 456 plants representing 34 individuals at Pu‘uwa‘awa‘a. In 2015, one plant was propagated representing one individual at Kīpāhoehoe, 19

plants representing three individuals at Manukā, and 311 plants representing 19 individuals at Pu'uwa'awa'a. In 2016, two plants were propagated representing two individuals at Manukā and 118 plants representing 11 individuals at Pu'uwa'awa'a. In 2017, two plants were propagated representing two individuals at Manukā and 323 plants representing 10 plants at Pu'uwa'awa'a. In 2018, 170 plants were propagated representing 12 individuals at Pu'uwa'awa'a. In 2019, only three plants were propagated representing one individual at Pu'uwa'awa'a (VRPF 2013- 2019). In summary, 64 collections from five locations have been propagated at VRPF, with the majority from Pu'uwa'awa'a. Currently, however, only one founder is represented ex situ. o In 2012, HVNP focused on seed collection with a total of 11 founders represented. In 2015, seeds and cuttings were collected from the Southwest Kahuku trees. In 2019, 16 seeds were collected from reintroduced plants at Manukā, two plants were propagated representing two individuals at Kīpuka Māmane, three plants were propagated representing two individuals at Nāulu, and three plants were propagated representing one individual at Ka'u (HVNP 2019a, pp. 9–10; HVNPb 2019). o In 2016, 38 seedlings were propagated from reintroduced plants and eight cuttings were propagated from one wild tree at Ka'ūpūlehu Dry Forest Preserve (Ka'ūpūlehu Dry Forest Preserve 2019). o Between 2014 and 2019, accessions were made from approximately 50 individuals at Palamanui (Palamanui 2019). o In 2018, 64 plants were propagated at Pu'uwa'awa'a (Pu'uwa'awa'a 2018). • Reintroduction and translocation— o In 2014, HVNP reported reintroduction of 100 plants at two new sites, Kīpukapepeiao and Hilina Pali. One year later survival was high at 88 percent. In 2015, 428 individuals were reintroduced at four sites: Kealakomo, Ka'aha, Kahuku, and Hilina Pali road. The best survival rate (89 percent) was at the Kahuku site. In 2016, 28 individuals were reintroduced at the Kahuku hala pepe exclosure and 50 were reintroduced at Kīpukapepeiao. In 2017, 225 plants were reintroduced at various sites. In 2018, 301 plants were reintroduced at Kīpukapepeiao. (HVNP 2019, pp. 9–10). o In 2019, the USDA Forest Service (for Pu'uwa'awa'a) reintroduced 42 C. hawaiiensis at Uhiuhi exclosure and 65 plants at Hauaina exclosure, Currently, the survivorship is 57 percent (Cordell-USDA Forest Service 2019). o In 2017, 66 C. hawaiiensis were reintroduced at four sites in Ka'ūpūlehu Dry Forest Preserve (Ka'ūpūlehu Dry Forest Preserve 2019). o In 2018, 37 plants were reintroduced at Pu'uwa'awa'a at two locations (Kīpuka 'Owē'owē and Hauaina reservoir) (Pu'uwa'awa'a 2018). o In 2013, the VRPF released three plants for reintroduction representing three individuals from Ocean View to Manukā, six plants representing one individual from Kīpāhoehoe to Manukā, and one plant representing one individual from Pu'uwa'awa'a back to Pu'uwa'awa'a. In 2014, one plant representing one individual from Ocean View was reintroduced to Manukā, six plants representing one individual from Kīpāhoehoe were reintroduced to Manukā, and 11 plants representing one individual from Kīpāhoehoe were reintroduced back to Kīpāhoehoe, six plants representing one individual from Kohala were reintroduced to Koai'a Tree Sanctuary, 25 plants representing two individuals from Manukā were reintroduced back to Manukā, 10 individuals representing one plant from Manukā were reintroduced to Kīpāhoehoe, and 178 plants representing five plants from Pu'uwa'awa'a were reintroduced back to Pu'uwa'awa'a. In 2015, two individuals representing one plant from Kohala were reintroduced back to Kohala, 11 plants representing two individuals from Manukā were reintroduced back to Manukā, and 268 individuals representing 15 plants from Pu'uwa'awa'a were reintroduced back to Pu'uwa'awa'a. In 2016, one individual representing one plant from Kīpāhoehoe was reintroduced to Manukā, one individual representing one plant from Kohala was reintroduced back to Kohala, 22 plants representing three plants from Manukā were reintroduced back to Manukā, and 248 plants representing 18 plants from Pu'uwa'awa'a were reintroduced back to Pu'uwa'awa'a. In 2017, 29 plants representing nine individuals from Pu'uwa'awa'a were reintroduced back to Pu'uwa'awa'a. No outplantings were reported in 2018. In 2019, 195 individuals representing 16 plants from Pu'uwa'awa'a were reintroduced back to Pu'uwa'awa'a (VRPF 2013-2019). In summary, at least 984 plants were

released for reintroductions to at least five sites were attempted between 2013 and 2019. (USFWS, 2020)

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS. 2012. Pleomele hawaiiensis (Hala pepe)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

U.S. Fish and Wildlife Service. 1998. Big Island II: Addendum to the Recovery Plan for the Big Island Plant Cluster. U.S. Fish and Wildlife Service, Portland, OR. 80 pages + appendices.

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants

Final Designation and Nondesignation of Critical Habitat for 46 Plant Species From the Island of Hawaii, HI. Final rule. 68 FR 39623 - 39722 (July 2, 2003).

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

USFWS 2012. Pleomele hawaiiensis (Hala pepe) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii.

USFWS 2012. Pleomele hawaiiensis (Hala pepe) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. USFWS. 2020. 5-YEAR REVIEW Short Form Summary Species Reviewed: Pleomele hawaiiensis (hala pepe). 12 pp.

USFWS. 2012. Pleomele hawaiiensis (Hala pepe) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

USFWS. 2020. 5-YEAR REVIEW Short Form Summary Species Reviewed: Pleomele hawaiiensis (hala pepe). 12 pp.

SPECIES ACCOUNT: *Poa atropurpurea* (San Bernardino bluegrass)

Species Taxonomic and Listing Information

Listing Status: Endangered; Pacific Southwest (R8) (USFWS, 2015)

Physical Description

A tufted perennial grass with erect stems, usually 3-4.5 dm tall. The inflorescence is spike-like, 3-7 cm long. In bloom late April-June or July. Male and female flowers are on separate plants. (NatureServe, 2015)

Historical Range

See current range/distribution.

Current Range

An unknown proportion of habitat for the species was initially lost in the 1880's via construction of the water impoundment that created Big Bear Lake. It is estimated that in addition to that initial habitat loss, 91 percent of the remaining historic habitat had been destroyed by 1998 (63 FR 49006-22), leaving just nine percent of its original range extant. Due to development, urbanization, and edge effects in Big Bear Valley since 1998, this remnant nine percent figure is probably an incorrect (high) estimate. In 1998, over 70 percent of the few remaining parcels of habitat for the species in Big Bear Valley were unprotected, and no populations in San Diego County were considered protected (63 FR 49006-49022). (USFWS, 2008)

Critical Habitat Designated

Yes; 8/14/2008.

Legal Description

On August 14, 2008, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Poa atropurpurea* (San Bernardino bluegrass) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes eight critical habitat units (CHUs), in California (73 FR 47706-47767).

Critical Habitat Designation

The critical habitat designation for *Poa atropurpurea* includes eight CHUs in San Bernardino and San Diego Counties, California. This species critical habitat encompasses approximately 2,489 acres (1,009 ha) (73 FR 47706-47767).

Unit 2: North Baldwin Meadow We are designating Unit 2 as critical habitat for both *Poa atropurpurea* and *Taraxacum californicum*. Unit 2 consists of approximately 177 ac (72 ha) of non-degraded meadow occupied by both species at the time of listing; both species continue to occur within this unit. Unit 2 contains all of the features essential to the conservation of both species. It is located within the SBNF, on the north shore of Baldwin Lake, and northeast of Big Bear Lake. Approximately half of Unit 2 is federally owned and half is owned by CDFG. Habitat in Unit 2 was historically impacted by authorized and unauthorized vehicle use, mining activity, residential development, and grazing by burros (CNDDDB 2006a, p. 1; SBNF 2002a, p. 33; SBNF 2002b, p. 57). The meadow is protected, but it is adjacent to State Route 18 and accessible to the public (SBNF 2000, p. 57). Disruption of the hydrologic regime by upstream development,

trampling during illegal woodcutting, and quartzite theft activities were identified as past threats in this unit (CNDDDB 2006b, p. 16). Additionally, *Poa atropurpurea* and *Taraxacum californicum* and their essential features are threatened in this unit by competition from invasion of nonnative, herbaceous annuals, and *T. officinale* has been reported to occur in this meadow (Krantz 2007, p. 2). Therefore, special management considerations or protection may be required to restore, protect, and maintain the essential features in Unit 2 due to the threats from upstream development, nonnative species invasion, hybridization, and human disturbance.

Unit 3: Belleville Meadow We are designating Unit 3 as critical habitat for both *Poa atropurpurea* and *Taraxacum californicum*. Unit 3 consists of an approximately 414-ac (168-ha) meadow occupied by both species at the time of listing; both species continue to occur within this unit. Unit 3 (also referred to as Upper Holcomb Valley) contains all of the features essential to the conservation of both species. Although most individuals of *P. atropurpurea* observed were reported to be male, both sexes are present (SBNF 2000, p. 47). In 1999, the *T. californicum* population in Unit 3 was reported to be “large” and “healthy” with no apparent *T. officinale* hybrids (SBNF 2000, p. 56). Although no hybrid individuals are reported from this meadow, recent reports indicate that *T. officinale* is present at this location and the two species could hybridize (Krantz 2007, p. 2). Unit 3 is located within the SBNF, north of Big Bear Lake, and east of Hitchcock Meadow (Unit 4). The majority of lands within this unit are federally owned (409 ac (166 ha)), with only 5 ac (2 ha) of meadow habitat privately owned by the Lithuanian Scouts Association. Meadow habitat in this Unit 3 may be impacted by recreational activities and nearby diffuse mining operations (CNDDDB 2006a, p. 6; Eliason 2007b); and placement of USFS roads has resulted in habitat loss and effects to meadow hydrology. Several areas of Belleville Meadow are currently heavily utilized for dispersed recreation, including vehicle use along the classified roads through the site, hiking and mountain biking along the Gold Fever Trail, and use of Holcomb Valley Campground near the western portion of the meadow. Additionally, several mining claims also exist in the meadow. Unauthorized vehicle activity and mountain biking off of classified roads and trails have caused devegetation and alteration of surface hydrology in some areas (SBNF 2002a, p. 36). Finally, *Poa atropurpurea* and *Taraxacum californicum* and their physical and biological features are threatened in this unit by invasion of nonnative, herbaceous annuals, and *T. officinale* has been reported to occur in this meadow (Krantz 2007, p. 2). The USFS erected signs and fencing and conducted outreach to protect occurrences in Unit 3 (SBNF 2002a, p. 37). For example, to reduce impacts to *Poa atropurpurea*, trails within Holcomb Valley Campground were disguised and rehabilitated, and the area was protected through barricading and signing (SBNF 2002a, p. 5). Nearby trails that did not pass through listed plant habitat were delineated and signed to encourage visitors to use those trails (SBNF 2002a, p. 5). However, special management considerations or protection may still be required to restore, protect, and maintain the essential features in Unit 3 due to the threats from human disturbance; current nearby mining activities; hybridization; and invasive, nonnative plant species.

Unit 4: Hitchcock Meadow We are designating Unit 4 as critical habitat for both *Poa atropurpurea* and *Taraxacum californicum*. Unit 4 consists of an approximately 497-ac (201-ha) meadow occupied by both species at the time of listing; both species continue to occur within this unit. Although *T. officinale* is present, no apparent hybrids have been reported (SBNF 2000, p. 56). We do not have any information about the ratio of male to female *P. atropurpurea* plants in this meadow. Unit 4 contains all of the features essential to the conservation of both species and is located within the SBNF, north of Big Bear Lake, and west of Belleville Meadow (Unit 3). The majority of Unit 4 (also referred to as Holcomb Valley) is privately owned by the Boy Scouts

of America (BSA) and used as a recreational and educational activity camp (BSA 2007, p. 1). Unit 4 has been historically impacted by OHV use, horse grazing, and other human disturbance (CNDDDB 2006b, p. 18). It is currently impacted by recreational and educational activities and horse grazing (SBNF 2000, p. 56; SBNF 2002a, p. 51). Additionally, *Poa atropurpurea* and *Taraxacum californicum* and their physical and biological features are threatened in this unit by invasion of nonnative, herbaceous annuals. Therefore, special management considerations or protection may be required to restore, protect, and maintain the essential features in Unit 4 due to the threats from past human disturbance; current camp activities; and invasive, nonnative plant species.

Unit 5: Bluff Meadow We are designating Unit 5 as critical habitat for both *Poa atropurpurea* and *Taraxacum californicum*. Unit 5 consists of an approximately 205-ac (83- ha) meadow occupied by both species at the time of listing; both species continue to occur within this unit. Although *T. officinale* is present, no hybrids are reported (SBNF 2000, p. 56). We do not have any information about the ratio of male to female *P. atropurpurea* plants in this meadow. Unit 5 contains all of the features essential to the conservation of both species. It is located within the SBNF, south of the west end of Big Bear Lake. The majority of Unit 5 is privately owned by the Wildlands Conservancy, and currently leased to the San Bernardino County Regional Parks Division as an outdoor science education camp (Wildlands Conservancy 2005). Unit 5 has been historically impacted by recreational activities, cattle grazing, and other human disturbance (CNDDDB 2006b, p. 12), although impacts are limited to recreational and educational activities (Eliason 2007b; SBNF 2000, p. 57; SBNF 2002a, p. 42). *Poa atropurpurea* and *Taraxacum californicum* and their physical and biological features are also threatened in this unit by invasion of nonnative, herbaceous annuals, including potential hybridization of *T. californicum* with *T. officinale* (SBNF 2000, p. 57; SBNF 2002a, p. 42). Therefore, special management considerations or protection may be required to restore, protect, and maintain the essential features in Unit 5 due to the potential impacts of past human disturbance; current camp activities; hybridization; and invasive, nonnative plant species.

Unit 11: Cienega Seca Meadow We are designating Unit 11 as critical habitat for both *Poa atropurpurea* and *Taraxacum californicum*. Unit 11 consists of an approximately 81-ac (33- ha) meadow occupied by both species at the time of listing; both species continue to occur within this unit. Although *T. officinale* is present, no hybrids are reported (SBNF 2000, p. 56). We do not have any information about the ratio of male to female *P. atropurpurea* plants in this meadow. Unit 11 contains all of the features essential to the conservation of both species. It is located within the SBNF adjacent to State Route 38, southeast of Big Bear Lake, and northeast of San Gorgonio Mountain. The majority of Unit 11 (also referred to Blue Sky Meadow) is privately owned by the Los Angeles County Education Foundation (LACEF), and currently used as an outdoor science education camp (Wildlands Conservancy 2007; LACEF 2007). Unit 11 has been historically impacted by changes in the hydrologic regime due to recreational activities, cattle grazing, and other human disturbance (CNDDDB 2006a, p. 2, 2006b, p. 2). Water usage from a well and vehicle use on some access roads are current threats to meadow habitat (SBNF 2002a, p. 77). *Poa atropurpurea* and *Taraxacum californicum* and their essential features are also threatened in this unit by invasion of nonnative, herbaceous annuals, including potential hybridization of *T. californicum* with *T. officinale* (CNDDDB 2006b, p. 2; SBNF 2000, p. 58). Therefore, special management considerations or protection may be required to restore, protect, and maintain the essential features in Unit 11 due to the threats from past human disturbance; current camp activities; hybridization; and invasive, nonnative plant species.

Unit 13: Mendenhall Valley We are designating Unit 13 as critical habitat for *Poa atropurpurea* only. Unit 13 consists of an approximately 291-ac (118-ha) meadow occupied by the species at the time of listing; the species continues to occur within this unit. This unit contains all of the features essential to the conservation of the species. It is located within the CNF on Palomar Mountain in San Diego County; 160 ac (65 ha) of the unit are federally owned, and the remaining portion (131 ac (53 ha)) is privately owned. We are not including a large portion of the meadow on the northwest end as critical habitat because a field survey determined that the habitat was degraded and of a different vegetative type (Anderson 2007, p. 1). The Mendenhall Valley meadow contains a geographically midrange population of *P. atropurpurea*, separated from the southern populations in Laguna Meadow and Bear Valley by at least 36 miles (58 km), and separated from the northern populations in the Big Bear Lake area by at least 60 miles (109 km). Habitat in Unit 13 has been impacted by cattle grazing (CNDDDB 2006a, p. 4; CNF 1991, pp. 13-17), land-use changes, and recreational activities (2006 GIS satellite imagery). Under a biological opinion resulting from Service consultation with the CNF (Service 2001, p. 5), annual surveys are to be conducted in this unit for *Poa atropurpurea*, and cattle are to be excluded from grazing on CNF land until mature seed has developed (set seed) on *P. atropurpurea*. Annual phenology monitoring is currently being conducted to ensure that *P. atropurpurea* has set seed prior to the start of grazing, which generally is permitted after May 1 in Mendenhall Valley (Winter 2007, p. 1). The USFS has also conducted ongoing gully repair work in this unit to benefit endangered meadow plants (Winter 2007, p. 3). Finally, *P. atropurpurea* and features essential to its conservation are threatened in this unit by invasion of nonnative, herbaceous annuals. Therefore, special management considerations or protection may be required to restore, protect, and maintain the essential features in Unit 13 due to threats from grazing and from invasive, nonnative plant species.

Unit 14: Laguna Meadow We are designating Unit 14 as critical habitat for *Poa atropurpurea* only. Unit 14 consists of an approximately 788-ac (319-ha) meadow occupied by the species at the time of listing; the species continues to occur within this unit. Although all five herbarium specimens collected in this unit and reviewed by Curto (1992, p. 3) were female (one from 1978, three from 1981, and one from 1991), Hirshberg (1994, p. 2) reported a 1:250 female to male ratio during field surveys. This unit contains all of the features essential to the conservation of the species. It is located on federally owned lands on Laguna Mountain within the CNF in San Diego County. Habitat in Unit 14 has been impacted by grazing and recreational activities (CNF 1991, pp. 13-17; CNDDDB 2006a, pp. 4 and 20). Under a biological opinion resulting from Service consultation with the CNF (Service 2001, p. 5), annual surveys are to be conducted in this unit for *Poa atropurpurea*, and cattle are to be excluded from grazing until completion of seed set is documented. The CNF does not permit grazing activities in Laguna Meadow until July 1; however, no annual surveys are currently being conducted because the grazing in this meadow starts several months after seed set occurs (Winter 2007, p. 1). Additionally, *P. atropurpurea* and features essential to its conservation are threatened in this unit by invasion of nonnative, herbaceous annuals. Therefore, special management considerations or protection may be required to restore, protect, and maintain the essential features in Unit 14 due to the threats from grazing and from invasive, nonnative plant species.

Unit 15: Bear Valley We are designating Unit 15 as critical habitat for *Poa atropurpurea* only. Unit 15 consists of an approximately 36-ac (15-ha) meadow occupied by the species at the time of listing; the species continues to occur within this unit. We do not have any information about the

ratio of male to female *P. atropurpurea* plants in this meadow. This unit contains all of the features essential to the conservation of the species. Unit 15 is federally owned and located within the CNF southwest of Laguna Mountain and south of the town of Pine Valley, San Diego County. Habitat in Unit 15 has been impacted by cattle grazing (CNDDDB 2006a, p. 21) and scattered irregular and diffuse recreational activities (2006 GIS satellite imagery). Under a biological opinion resulting from Service consultation with the CNF (Service 2001, pp. 3 and 4), annual surveys would be conducted in this unit for *Poa atropurpurea*, and cattle are to be excluded from grazing until mature seed has developed on *P. atropurpurea*. The CNF does not permit grazing activities in Bear Valley until August 1; however, no annual surveys are currently being conducted because the grazing in this meadow starts several months after seed set occurs in late April (Winter 2007, p. 1). *Poa atropurpurea* and features essential to its conservation are also threatened in this unit by invasion of nonnative, herbaceous annuals. Therefore, special management considerations or protection may be required to restore, protect, and maintain the essential features in Unit 15 due to the threats from grazing; human disturbance associated with recreation; and invasive, nonnative plant species.

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 *Poa atropurpurea* critical habitat consists of two components (73 FR 47706-47767):

- (i) Wet meadows subject to flooding during wet years in the San Bernardino Mountains in San Bernardino County at elevations of 6,700 to 8,100 feet (2,000 to 2,469 meters), and in the Laguna and Palomar Mountains of San Diego County at elevations of 6,000 to 7,500 feet (1,800 to 2,300 meters), that provide space for individual and population growth, reproduction, and dispersal; and
- (ii) Well-drained, loamy alluvial to sandy loam soils occurring in the wet meadow system, with a 0 to 16 percent slope, to provide water, air, minerals, and other nutritional or physiological requirements to the species.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the areas occupied at the time of listing contain the features essential to the conservation of the species that may require special management considerations or protection. Major threats to *Poa atropurpurea* and *Taraxacum californicum*, and, therefore, to the features essential to their conservation, include development on private lands, grazing, off-highway vehicle (OHV) use, road maintenance activities, ground disturbance that affects surface hydrology, mining activities, recreational activities, habitat fragmentation, and the invasion of nonnative herbaceous plants. Please refer to the unit descriptions in the "Final Critical Habitat Designations" section for further discussion of special management considerations or protection of the physical and biological features related to geographically specific threats to *P. atropurpurea* and *T. californicum*. Special management considerations or protection of the wet meadows may be needed to address concerns such as reducing nonnative plant invasions and maintaining populations. Control and monitoring of nonnative, invasive plant species may be required to maintain wet meadows and or forest openings such that they can continue to support populations of *Poa atropurpurea* and or *Taraxacum californicum*. Nonnative species alter the meadow habitat by creating mats of thatch which cover bare ground needed for *P. atropurpurea* and *T. californicum* to become established,

and also use water resources that could be used by *P. atropurpurea* and *T. californicum*. The growth of nonnative species may adversely impact and change the physical and biological features of the meadow habitat. Implementing management actions that support fertilization and seed set of *P. atropurpurea* (Curto 1992, p. 11; Soreng 2000, pp. 1–4), and provide monitoring and protection of male *P. atropurpurea* clones may be required to maintain populations of *P. atropurpurea*. Special management considerations or protections for wet meadow habitat may need to be implemented to control the impacts associated with direct competition and hybridization caused by the nonnative *Taraxacum officinale*. This nonnative species occupies open niches, which can reduce the bare ground needed for *T. californicum* to become established, and may alter the physical and biological features of the meadow habitat. Management may include the removal of *T. officinale* from montane meadows where this species co-occurs with *T. californicum*. Additionally, it may be appropriate to remove hybridized individuals; however, we believe this course of action warrants further investigation. There are two USFS management guides that address conservation of *Poa atropurpurea* and *Taraxacum californicum*: (1) The CNF Habitat Management Guide for the Sensitive Plant Species: *Delphinium hesperium* ssp. *cuyamaca*, *Lilium parryi*, *Limnanthes gracilis* var. *parishii*, and *P. atropurpurea*, in Riparian Montane Meadows (CNF 1991, pp. 1–36) addresses conservation of *P. atropurpurea*; and (2) the SBNF Meadow Habitat Management Guide (SBNF 2002a pp. 1–155) addresses conservation of both species. In some cases, significant management actions have been implemented by the USFS (for example, cattle exclosures in Laguna Meadow (CNF 1991, p. 17), recreational trail closures in Belleville Meadow near Big Bear Lake (SBNF 2002a, p. 5)).

Life History

Food/Nutrient Resources

Breeding Season

Adult: *Poa atropurpurea* flowers from April to July depending on local and seasonal weather conditions and elevation (Curto 1992; Soreng 1993) (USFWS, 2008).

Reproduction Narrative

Adult: *Poa atropurpurea* flowers from April to July depending on local and seasonal weather conditions and elevation (Curto 1992; Soreng 1993). Co-occurrence of male and female plants is necessary for sexual reproduction. For example, if all remaining individuals in a population were only one sex, the population would eventually be locally extirpated due to senescence of older individual plants (Curto 1992, p. 3; Soreng 2000, p. 1–4). Hirshberg (1994, pp. 1, 2) reported only 4 males out of approximately 1140 total individuals during field surveys of Laguna Meadow, an overall 1:285 male to female ratio. All 5 herbarium specimens from Laguna Meadow reviewed by Curto (1992, p. 3) were female (one from 1978, three from 1981, and one from 1991). Distribution of sexed individuals is an important parameter to understand potential for species retention in suitable habitat; however these data have not been collected to date in other meadows or in subsequent years at Laguna Meadows (USFWS, 2008).

Habitat Type

Adult: Meadows (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Species inhabits the edges of moist meadows at 1500-2300 m elevation. (NatureServe, 2015). High ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the specific habitat requirements of this species and the low number of known populations.

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Decreasing (USFWS, 2008)

Number of Populations:

29 (USFWS, 2020)

Population Narrative:

There are currently 29 occurrences of *Poa atropurpurea* across the species' range. A total of 27 occurrences are considered extant or presumed extant, 1 is vague, and 1 is extirpated. Since the last 5-year review in 2008, 9 of the 27 occurrences have been observed (Table 1). (USFWS, 2020)

Threats and Stressors

Stressor: Grazing (USFWS, 2008)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Grazing continues to be permitted on National Forest managed lands in the CNF. Grazing also causes trampling of the plants (along with herbivory) (USFWS, 2008).

Stressor: Development (USFWS, 2008)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Residential and commercial development are listed as threats to this species (USFWS, 2008).

Stressor: Recreational activities (USFWS, 2008)

Exposure:**Response:****Consequence:** Loss of individuals/loss of habitat**Narrative:** Recreational activities (e.g. off-road vehicles and off trail hiking) is listed as a threat to this species (USFWS, 2008).**Stressor:** Altered hydrological regimes (USFWS, 2008)**Exposure:****Response:****Consequence:** Loss of habitat

Narrative: Periodic droughts compounded by water table effects were indicated as a threat to *Poa atropurpurea* in the listing rule (63 FR 49012). Periodic and successive droughts are considered an underestimated ecological stress and selection factor that impacts forest and glade biological diversity, and depend on species' specific ability to withstand a drought period (Gutschick and BrassiriRad 2003; Archaux and Wolters 2006). Following the species listing, an extended drought in the region (San Diego County Water Authority 2007) has created unusual habitat conditions. From 1996 to 2005 at the closest precipitation gauge to the southern population (Lake Cuyamaca, San Diego County, CA), seven of 10 years had precipitation significantly below normal for all recorded time (San Diego County Water Authority 2007). Invasive plant species incursion has been exacerbated by the changing water regime, and presence of non-native grazers such as sheep and cattle. The cumulative effect of these threats to *P. atropurpurea* populations is unknown. The extended drought in the mountains of southern California may be the leading edge of climate change affecting, summarily altering and eliminating lower latitude upper elevation montane habitat, causing additional loss of available habitat. At the foreseeable extreme suggested by climate models, global warming induced climate change has the potential to cause an upward biological elevation shift (see Fleishman et al. 1998; Parmesan 2006), which would establish a different vegetative regime and partial to complete loss of upper elevation vernal meadow habitat for *Poa atropurpurea*. Any significant elevational shift in ecological regimes would likely result in loss of concentrations of this species, resulting in eventual extinction (USFWS, 2008).

Stressor: Telephone line trenching (USFWS, 2008)**Exposure:****Response:****Consequence:** Loss of habitat**Narrative:** Telephone line trenching is listed as a threat to this species (USFWS, 2008).**Stressor:** Road maintenance (USFWS, 2008)**Exposure:****Response:****Consequence:** Loss of habitat**Narrative:** Road maintenance is listed as a threat to this species (USFWS, 2008).**Stressor:** Soil removal (USFWS, 2008)**Exposure:****Response:****Consequence:** Loss of habitat**Narrative:** Soil removal is listed as a threat to this species (USFWS, 2008).

Stressor: Intentional grading (USFWS, 2008)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Intentional grading is listed as a threat to this species (USFWS, 2008).

Stressor: Predation (USFWS, 2008)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Soreng (63 FR 49006-22) suggested thrip damage to *P. atropurpurea* in Big Bear Valley may cause the reduction in seed set. Predation effect by thrips may not be a threat to the species singularly; however additive or synergistic effects of other threats (i.e. grazing, fragmentation of habitat, etc.) may cumulatively eliminate seed production by *P. atropurpurea* in some areas of its range (USFWS, 2008).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2008)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Other than the Endangered Species Act, existing laws and regulations provide extremely limited protection for *P. atropurpurea*, such as where the species and/or its habitat may be impacted (i.e., Clean Water Act). These protections are applied sporadically throughout the range of *Poa atropurpurea*, and are currently inadequate to comprehensively address the threats to the species. These laws do not specifically address impacts from competing human recreational use and/or disturbance, grazing, and non-native vegetation, all of which remain primary threats to *P. atropurpurea* (USFWS, 2008).

Stressor: Climate change (USFWS, 2008)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Climate change is likely to increase the scale and intensity of wildlife in southern California. Conflagrations pose the largest single stochastic risk to the few remaining small and declining concentrations of *Poa atropurpurea*. Small fires in the San Bernardino and Laguna mountains will most likely turn into large conflagrations (size class E-G (300 - + 5,000 acres) due to wind, weather, lack of prescribed fires, invasive vegetation, and wildfire control/prevention response. As an example, the recent fire (Windy Ridge fire), that occurred on March 11, 2007 near Orange, California, turned into a size class F (1,000 – 4999.9 acres) in less than 12 hours (USFWS, 2008).

Stressor: Small and declining populations (USFWS, 2008)

Exposure:

Response:

Consequence: Lack of genetic variability/extinction

Narrative: No empirical information is available to determine the finite rate of population change (?) or time to extinction for the species, however by all accounts; the species habitat within the

range of natural variability and resulting populations have decreased since the time of listing even when locations of new sightings of scattered individuals are considered. Currently, the Service does not have information on the quality or quantity of habitat for this species on the remaining private land parcels in Big Bear Valley or in the Laguna Mountains (USFWS, 2008).

Recovery

Recovery Actions:

- No recovery plan or outline has been completed for this species (USFWS, 2008).
- Conduct field assay at each known *Poa atropurpurea* site to gather data on a) presence, b) sex ratio and age class structure, c) threats, and d) conservation needs (USFWS, 2008).
- Provide viable seeds from *Poa atropurpurea* to a seed bank operating under the Center for Plant Conservation guidelines (USFWS, 2008).
- Foster focused partnership with the Forest Service to promote habitat protection and annual surveys on occupied and suitable *Poa atropurpurea* habitat (USFWS, 2008).
- Determine the nature and needs of seed production to seedling establishment (USFWS, 2008).
- Develop cooperative relationships with private landowners to survey potential habitat, and create land easements to protect extant and potential habitat, and manage or eliminate cattle grazing on known *Poa atropurpurea* habitat in order to assure successful reproduction and seed set (USFWS, 2008).
- Craft and complete critical habitat designation, final recovery plan, and conservation strategy that provide guidance for best management practices and discussion of jeopardy threshold (USFWS, 2008).
- If sex and age class distribution dictate, develop and implement a controlled propagation, reintroduction, and monitoring program to conserve *Poa atropurpurea* from extirpation and/or extinction, consistent with USFWS policy (65 FR 56916-56922) (USFWS, 2008).

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** The actions listed below are recommendations to be completed over the next 5 years. These actions will help guide recovery of *Poa atropurpurea* by conserving *P. atropurpurea* habitat and occurrences, ameliorating threats to habitat and individuals, supporting research opportunities, and coordinating survey and monitoring efforts. The conservation of *P. atropurpurea* will require continued cooperation and coordination with partners—including Tribes, private landowners, and Federal, State, and local agencies—to minimize impacts from current threats and assist with species recovery. We will also work with USFWS programs, such as the USFWS's Partners for Fish and Wildlife, to identify opportunities for conservation on private lands. Property easements or purchases of parcels could also be made through the Act's section 6 funding, or other funding opportunities. 1. Conserve *Poa atropurpurea* occurrences and meadow habitat: a. Continue to work with Forest Service, State, and conservation organizations to purchase *P. atropurpurea* occupied and suitable habitat from willing sellers. b. Continue to work with local partners to identify an appropriate entity or entities to hold and manage conservation easements that protect *P. atropurpurea* habitat. c. Provide private landowners with information about *P. atropurpurea* habitat, and explore opportunities for partnership and conservation. d. Continue to work with the Big Bear City Community Services District to adopt and implement the draft Pan Hot Springs Habitat Management Plan. 2. Support research to resolve questions about *Poa atropurpurea* life history, ecology, and genetics: a. Study meadow hydrology

and better determine threats at *P. atropurpurea* occurrences. b. Investigate reproductive life history characteristics such as seed germination requirements, mechanism of seed dispersal, and seed viability. c. Investigate seedling establishment and time to reach maturity. d. Conduct studies to resolve questions of: i) skewed sex ratios, ii) distribution of genetic diversity in the species, and iii) potential introgression/hybridization with other *Poa* taxa. e. Determine the environmental needs and constraints of the species. f. Conduct research to inform meadow restoration and reintroduction efforts. 3. Support efforts to survey *Poa atropurpurea* occurrences. Monitor population trends of *P. atropurpurea*. Soreng suggested that monitoring should map the spatial extent of the occurrence and include estimates of number of individuals or “clumps,” number of flowering individuals, sex ratios of pistillate to staminate plants, and seed production (Soreng 2007b, p. 4). 4. Identify potential areas for restoration and conduct studies of restoration techniques. Support partners in efforts to restore habitat and re-establish populations at historical locations. (USFWS, 202)

References

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

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed June 2016.

USFWS 2008. (*Poa atropurpurea*) San Bernardino Bluegrass 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office Carlsbad, CA. Accessed June 2016.

U.S. Fish and Wildlife Service. 2008. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for *Poa atropurpurea* (San Bernardino bluegrass) and *Taraxacum californicum* (California taraxacum). Final rule

administrative revisions. 73 FR 47706-47767 (August 14, 2008).

U.S. Fish and Wildlife Service. 2008. (*Poa atropurpurea*) San Bernardino Bluegrass Five-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Service Office Carlsbad, California

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.” USFWS. 2020. 5-YEAR REVIEW *Poa atropurpurea* (San Bernardino bluegrass). 26 pp.

U.S. Fish and Wildlife Service. 2008. (*Poa atropurpurea*) San Bernardino Bluegrass Five-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Carlsbad Fish and Wildlife Service Office Carlsbad, California.

U.S. Fish and Wildlife Service. 2008. (*Poa atropurpurea*) San Bernardino Bluegrass

Five-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Service Office, Carlsbad, California.

USFWS. 2020. 5-YEAR REVIEW *Poa atropurpurea* (San Bernardino bluegrass). 26 pp.

SPECIES ACCOUNT: *Poa napensis* (Napa bluegrass)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/21/1997; Pacific Southwest (R8)

Physical Description

Poa napensis is an erect, tufted perennial bunchgrass in the grass family (Poaceae) that grows to 1 dm (4 in) in height. Leaves are folded, stiffly erect, 1 mm (0.04 in) wide, with the basal leaves 20 cm (8 in) long and upper stem leaves to 15 cm (6 in) in length. A few stiff, erect flowering stems appear in May and grow 7 dm (27 in) in height. Flower clusters occur as a pale green to purple, condensed, oblong-oval panicle 10 to 15 cm (4 to 6 in) long and 2 to 5 cm (0.8 to 2.0 in) wide. *Poa napensis* most closely resembles *P. unilateralis* (ocean bluff bluegrass), but differs in leaf and panicle form and habitat. (USFWS, 1997)

Taxonomy

Alan Beetle first described *Poa napensis* in 1946 from specimens that he collected in a meadow moistened by seepage from hot springs, 3 km (2 mi) north of Calistoga at Myrtdale Hot Springs, Napa County, California. This treatment was retained by Soreng (1993). (USFWS, 1997)

Historical Range

See current range/distribution.

Current Range

Known only from 3-kilometer (2-mile) radius of Calistoga, in Napa County, California. (USFWS, 2010)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Breeding Season

Adult: A few erect flowering stems appear in May and grow as much as 69 centimeters (27 inches) in height (USFWS, 2010).

Reproduction Narrative

Adult: A few erect flowering stems appear in May and grow as much as 69 centimeters (27 inches) in height. Pale green to purple flowers bloom in condensed, round-shaped clusters at the end of the few flowering stems (USFWS, 2010).

Habitat Type

Adult: Moist meadows (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: *Poa napensis* is typically found in alkaline meadows and grasslands, mesic areas including vernal pools, next to and fed by hot springs and small geysers. The 2009 WRA survey identified *Poa napensis* growing in short, sparsely vegetated areas as well as in tall and densely vegetated upland grassland and wetland swales on the airport property. Although *P. napensis* is known to grow in wetlands, it occurs on the airport property in sparsely vegetated bare soil 'scald' areas which are associated with *Plagiobothrys strictus* (WRA 2009). (USFWS, 2010)

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Decreasing or unknown (inferred from USFWS, 2010)

Number of Populations:

2 (USFWS, 2010)

Population Size:

~250 individuals in one population; unknown for other population (USFWS, 2010)

Population Narrative:

At the time of listing, *Poa. napensis* was only known from two populations in the vicinity of Calistoga (California Native Plant Society 2008b). A 2008 survey conducted by Glenn Lukos Associates identified approximately 520 *P. napensis* plants at 26 locations on the airport property. A March 9, 2009 EcoSystems West Consulting Group survey identified 244 individual *Poa napensis* plants at 31 locations on the airport property (WRA 2009). The second population of *Poa napensis* is scattered over a 4 hectare (10 acre) area bisected by an asphalt road on private land in Calistoga. In recent years, the landowner has denied access to the site, and no current information on the size of this population is available (Symonds, pers. comm. 2008). During the airport property observations in April and May 2008, Ms. Symonds also confirmed *Poa napensis* was present. She noted that plants were growing on the rim of a vernal pool as well as along the property fence line. Formal protocol-level, botanical surveys to assess plant abundance were not conducted during the April and May 2008 visits (Symonds, pers. comm. 2008). Additional observations by Ms. Symonds and other biologists in September 2008, confirmed *P. napensis* is present on the edge of the property and was observed growing on either side of the property fence line (Kasparian, pers. obs. 2008). (USFWS, 2010). Historically, Napa bluegrass likely had larger populations before hot spring resources were developed in the

Calistoga region (Department 1989, p. 2). The Napa bluegrass population at the airport property was thought to be extirpated due to construction activities that took place in 1981. However, prior to listing hundreds of Napa bluegrass plants were counted at the airport property from 1987 to 1996 (Service 1997, p. 55799). Prior to the 2010 status review, in 2008, approximately 520 Napa bluegrass plants at 26 locations on the airport property were identified and in 2009 a survey during the blooming period found 244 plants at 31 locations on the airport property (WRA 2009, p. 1; Service 2010, p. 6). There have been no surveys of the Napa bluegrass on the airport property since the 2010 status review. In the early 1980s prior to listing, the Napa bluegrass population at the hot spring property was comprised of several thousand plants (Service 1997, p. 55799). Access to the hot spring property has been denied since the years preceding listing (Service 1997, p. 55799; Service 2010, p. 6), so surveys have not been carried out at the property (USFWS, 2023).

Threats and Stressors

Stressor: Airport activities (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: One of the populations of each species occurs at the airport property, and future development at this site could threaten these populations (USFWS, 2010).

Stressor: Alteration of hydrology (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: *Poa napensis* is dependent on hot springs and geysers for its survival. Alterations in the hydrology of the hot springs or geysers overland flow would pose a threat to this plant by removing the supply of acidic water which maintains the suitability of the habitat. Such alterations would include, but not be limited to, new water well drilling into underground water sources or increasing the draw-down from existing wells (Service 1997) (USFWS, 2010).

Stressor: Urbanization (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: The occurrences of the two species on the second private parcel (Myrtledale Hot Springs) in the City of Calistoga had been proposed for a new hospital. Because *Poa napensis* and *Plagiobothrys strictus* occur at both the airport property and on another private property, the threats from urbanization, including possible future development, are the same for both species. Future development at either site could threaten either or both species (USFWS, 2010).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: In summary, the California and Federal Endangered Species Acts are the primary State and Federal laws, respectively, that provide protection for this species since its listing as

endangered in 1997. Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Endangered Species Act (USFWS, 2010).

Stressor: Human activities (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: *Poa napensis* individuals within the Myrtdale Hot Springs population could be lost to trampling should the number of hikers increase to the hot spring, the paved road is widened, or the property owner decides to alter the landscape causing the alteration of hydrology. Because the most recent observation of six *Poa napensis* individuals was in 2007 and conducted from outside the property boundary (Occurrence #1, CNDDDB 2009b), the risk of human activities may be even greater since a more accurate count of individuals does not exist currently. The former Calistoga airport parcel could be mowed or its hydrology could be altered presenting unknown magnitude of risk to the populations of either species since neither population has been thoroughly surveyed since 1996 (*P. napensis* Occurrence #3 and *Plagiobothrys strictus* Occurrence #3, CNDDDB 2009a) (USFWS, 2010).

Stressor: Restricted habitat, range, and few numbers of populations (USFWS, 2010)

Exposure:

Response:

Consequence: Extinction/loss of genetic variability

Narrative: Species in natural habitats face threats both from deterministic facts such as habitat loss, overexploitation, pollution, introduced species, and stochastic events associated with small population size. Such events may be of a demographic genetic or environmental nature, including catastrophes (World Conservation Monitoring Centre 1992). The estimated population size for *Plagiobothrys strictus* was over 5,000 individuals in 1994 (Occurrence # 3, CNDDDB 2009a) and six plants in 2007 as observed from the edge of the second property boundary for *Poa napensis* (Occurrence #1, CNDDDB 2009b). Both species' populations could be susceptible to extirpation from random events due to their restricted range. Increased homozygosity resulting from genetic drift and inbreeding may lead to a loss of fitness (ability of individuals to survive and reproduce) in small populations (Menges 1991; Ellstrand and Elam 1993) (USFWS, 2010).

Stressor: Invasive species (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Competition from invasive plant species poses a potential threat to both species. Exotic and/or invasive, weedy plant species reduce native plant diversity and diminish the habitat suitability for native species; this is particularly the case in sensitive habitats (G. Cooley, California Department of Fish and Game, pers. comm. 2008). The consistent pattern of heavy growth of nonnative grasses when not controlled by grazing or other management can 'smother' native plants, resulting in the subsequent crowding out, outcompeting, or overshadowing of native annuals. A common consequence of such heavy annual grass growth is development of thatch, which adds to the strong smothering effect by inhibiting annuals' germination and growth (Weiss

et al. 2007) (USFWS, 2010).

Stressor: Climate change and drought (USFWS, 2010)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: A modeling study completed by Loarie et al. (2008) provides an evaluation of potential trends to California's floristic communities under climate change scenarios. In general, plant diversity will shift in two divergent directions: along the coast and northwards at higher elevations; and southwards at higher elevations of the Sierra Nevada. The models suggest that climate change has the potential to break up local floras, resulting in new species combinations, with new patterns of competition and biotic interactions (Loarie et al. 2008). Based on these modeling results, *Plagiobothrys strictus* and *Poa napensis* plants could be unable to shift their range because of their isolated, small populations, whose growth depend upon particular hydrological regimes, and the limited available, suitable habitat surrounding the two private parcels (USFWS, 2010).

Recovery

Reclassification Criteria:

Not defined; a recovery plan or outline has not been completed. (USFWS, 2010)

Recovery Priority Number: 5C

Delisting Criteria:

Not defined; a recovery plan or outline has not been completed. (USFWS, 2010)

Recovery Actions:

- Not defined; a recovery plan or outline has not been completed. (USFWS, 2010)
- Work with the landowners, the California Department of Fish and Game, the City of Calistoga, and California Native Plant Society to ameliorate or eliminate any threats to *Plagiobothrys strictus* and *Poa napensis* from hydrological changes and from competition from nonnative plants (USFWS, 2010).
- Collect seeds from both species from both parcel sites and store them in Center for Plant Conservation certified botanic gardens to guard against extirpation of populations from chance catastrophic events (USFWS, 2010).
- Follow conservation measures and policies as stated in the 2007 Napa County General Plan Update (USFWS, 2010).
- Follow conservation measures and policies as stated in the 2003 City of Calistoga General Plan for sensitive plant species (USFWS, 2010).
- Conduct a population assessment for each species and continue monitoring over the next 5 years (USFWS, 2010).
- Work with the landowners, the California Department of Fish and Game, the City of Calistoga, and California Native Plant Society to ensure the protection of all known populations of *Plagiobothrys strictus* and *Poa napensis*. (USFWS, 2010)

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS:** Here we propose several habitat conservation and ecological research recommendations which will aid in the recovery and conservation of *Calistoga allocarya* and Napa bluegrass. Some of these recommendations were discussed in the last status review (Service 2010, p. 16) and remain valid. 1. Partner with private landowners, the California Department of Fish and Wildlife, the City of Calistoga, and the California Native Plant Society to ensure protection of all known populations of *Calistoga allocarya* and Napa bluegrass. 2. Work with the California Department of Fish and Wildlife, the City of Calistoga, and the California Native Plant Society to ameliorate or eliminate any threats to *Calistoga allocarya* and Napa bluegrass from hydrological changes and competition from invasive plants. 3. Collect seeds from both populations of both species and store them in Center for Plant Conservation certified botanic gardens to guard against extirpation from chance catastrophic events. 4. Follow policy CON-17 and associated conservation measures as stated in the Napa County General Plan to “Preserve and protect native grasslands, serpentine grasslands, mixed serpentine chaparral, and other sensitive biotic communities and habitats of limited distribution” (Napa County Department of Conservation, Development, and Planning 2009, p. CON-28). 5. Follow policies P1.1-3 and P1.1-4 and associated actions as stated in the Open Space and Conservation Element (Updated 2012) of the City of Calistoga General Plan to continue “efforts to identify and map biological resources on the gliderport property [airport property], which provides an important and unique habitat area within the city limits” and “explore the possibility of designating parcels as Natural Resource Preservation Areas in areas of the city known to contain sensitive and unique species, in order to protect these resources” (City of Calistoga 2012, p. OSC-23). 6. Conduct a population assessment for each species and continue monitoring annually (USFWS, 2023).

References

USFWS. 1997. Determination of Endangered Status for Nine Plants from the Grasslands or Mesic Areas of the Central Coast of California. Final Rule. 62 FR 55791 - 55808 (October 22, 1997).

USFWS. 2010. *Plagiobothrys strictus* (*Calistoga allocarya*), *Poa napensis* (Napa bluegrass), 5-Year Review. U.S. Fish and Wildlife Service. Sacramento, California. 23 pp. February 16, 2010. https://ecos.fws.gov/docs/five_year_review/doc3218.pdf

USFWS. 2010. *Plagiobothrys strictus* (*Calistoga allocarya*), *Poa napensis* (Napa bluegrass), 5-Year Review. U.S. Fish and Wildlife Service. Sacramento, California. 23 pp. February 16, 2010. https://ecos.fws.gov/docs/five_year_review/doc3218.pdf. USFWS. 2023. 5-YEAR REVIEW *Calistoga Allocarya* (*Plagiobothrys strictus*) Napa Bluegrass (*Poa napensis*). Sacramento Fish and Wildlife Office. Sacramento, California. 8 pages.

U.S. Fish and Wildlife Service. 2010. *Plagiobothrys strictus* (*Calistoga allocarya*) *Poa napensis* (Napa bluegrass) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California.

USFWS. 2023. 5-YEAR REVIEW *Calistoga Allocarya* (*Plagiobothrys strictus*) Napa Bluegrass (*Poa napensis*). Sacramento Fish and Wildlife Office. Sacramento, California. 8 pages.

SPECIES ACCOUNT: *Pritchardia bakeri* (Lo`ulu)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/31/2016; Pacific Region (R1) (USFWS, 2017)

Physical Description

Pritchardia bakeri (Baker's loulu) is a small to medium-sized palm in the palm family (Arecaceae). This palm species, endemic to Oahu, is 23 to 30 ft (7 to 10 m) tall, with a smooth, grayish trunk 8 to 10 in (20 to 25 cm) in diameter. Its crown contains up to 40 ascending to stiffly spreading leaves, 2 to 3 ft (0.6 to 0.9 m) long and wide, on 1 to 2 ft (0.3 to 0.6 m) leaf stalks. The leaf blades are glossy green above and silvery grayish below. The flower and fruit stalks have up to three long primary branches that are nearly equal in length to the leaf when in flower, but greatly exceed the leaf length when in fruit. Fruit are shiny, black, and spherical, up to 2 in (5 cm) long and 2 in (4 cm) wide when mature (Hodel 2009, pp. 173–179; Hodel 2012, pp. 70–73) (USFWS, 2015).

Taxonomy

Pritchardia bakeri was first described as a new species in 2009 by Hodel (pp. 173–179). *Pritchardia bakeri* is recognized as a distinct taxon by Hodel (2009, pp. 173–179; 2012, pp. 70–73), the most currently accepted taxonomic treatments of this species (USFWS, 2015).

Historical Range

Known from the northern end (Pupukea) and southern end (Kuliouou) of the Koolau Mountain range, Oahu. (NatureServe, 2015)

Current Range

This palm occurs on the northern end (Pupukea) and southern end (Kuliouou) of the Koolau Mountain range, on the island of Oahu (Bacon et al. 2012, pp. 1–17; Hodel 2012, pp. 71–73) (USFWS, 2015).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Habitat Type

Adult: Terrestrial (USFWS, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Shrub/grass land (USFWS, 2015)

Dependencies on Specific Environmental Elements

Adult: Lowland mesic ecosystem (USFWS, 2015)

Geographic or Habitat Restraints or Barriers

Adult: 1,500 to 2,100 ft. elevation (USFWS, 2015)

Habitat Narrative

Adult: Pritchardia bakeri occurs in the lowland mesic ecosystem in the Koolau Mountains on Oahu, at 1,500 to 2,100 ft (457 to 640 m), in disturbed, windswept, and mostly exposed shrubby or grassy areas, and sometimes on steep slopes in these areas (Hodel 2012, pp. 71–73) (USFWS, 2015).

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Declining (USFWS, 2015; 2016)

Number of Populations:

2 (USFWS, 2021)

Population Size:

~30 (USFWS, 2021)

Population Narrative:

Currently, occurrences total fewer than 100 individuals (Ching Harbin 2015, in litt.) (USFWS, 2016). Previously, occurrences totaled approximately 250 individuals (Hodel 2012, pp. 42, 71) (USFWS, 2015). There are two populations totaling approximately 30 individuals of Pritchardia bakeri on O‘ahu. Pritchardia bakeri is likely vulnerable to the effects of climate change. Seed collection and propagation for storage are ongoing. (USFWS, 2021)

Threats and Stressors

Stressor: Feral pigs (USFWS, 2015)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Habitat modification and destruction by feral pigs affect the range and abundance of Pritchardia bakeri (USFWS, 2015).

Stressor: Rats (USFWS, 2015)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Rats eat the fruit before they mature (Hodel 2012, pp. 42, 73) (USFWS, 2015).

Stressor: Nonnative plants (USFWS, 2015)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Nonnative plants compete with and degrade and destroy native habitat of *P. bakeri* and displace this species and other native Hawaiian plants by competing for water, nutrients, light, and space, or they may produce chemicals that inhibit growth of other plants (Smith 1985, pp. 180– 250; Vitousek et al. 1987 in Cuddihy and Stone 1990, p. 74) (USFWS, 2015).

Stressor: Stochastic events (USFWS, 2015)

Exposure:

Response:

Consequence: Extinction/Loss of habitat

Narrative: Stochastic events such as hurricanes modify and destroy the habitat of *P. bakeri*, and can damage or kill plants (USFWS, 2015).

Stressor: Reduced reproductive vigor (USFWS, 2015)

Exposure:

Response:

Consequence: Extinction

Narrative: This species may experience reduced reproductive vigor due to low levels of genetic variability caused by seed predation by rats and widely separated occurrences, leading to diminished capacity to adapt to environmental changes, and thereby lessening the probability of long-term persistence (Barrett and Kohn 1991, p. 4; Newman and Pilson 1997, p. 361; Hodel 2012, p. 73) (USFWS, 2015).

Stressor: Climate change (USFWS, 2016)

Exposure:

Response:

Consequence:

Narrative: The effects of climate change are expected to exacerbate the threats to *P. bakeri* (USFWS, 2016).

Recovery

Recovery Actions:

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

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** • Surveys and inventories—Continue to conduct surveys for *Pritchardia bakeri* in historical locations and potentially suitable habitat. • Ungulate monitoring and control—Construct and maintain fenced exclosures to protect individuals from the negative impacts of feral ungulates. • Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species and those that compete with *P. bakeri* at managed populations. • Control of predation and herbivory by rats and invertebrates—Implement and/or develop effective control measures for rats and the CRB at all populations. • Overcollection—Develop and implement management and control of illegal collection and sale of seeds and plants of *P. bakeri*. • Captive propagation for genetic storage and reintroduction—Continue to collect seeds for storage and propagation efforts for maintenance of genetic stock. • Reintroduction and translocation—Increase numbers of populations and individuals in suitable habitat to build resiliency and redundancy and reduce the impacts of isolated, small populations and climate change. • Climate change adaptation strategy—Research suitability of

habitat in the future due to the impacts of climate change. • Alliance and partnership development—Continue to contribute to planning and implementation of ecosystem-level restoration and management to benefit this taxon. (USFWS, 2021)

- Current Management Actions: • Surveys and monitoring—The State of Hawai'i's Plant Extinction Prevention Program (PEPP) surveys for and monitors populations (PEPP 2011, 2013, 2018). • Captive propagation for genetic storage and reintroduction—
 - o In 2018-2019, the Waimea Valley Arboretum reported storage of 14 plants/seeds representing two founders (Waimea Arboretum 2018, 2019).
 - o Lyon Micropropagation Laboratory reports storage of 28 containers of propagules representing one founder from the southern Ko'olau mountains (Lyon Arboretum 2020).
 - o The State's Rare Plant Facility at Pahole on O'ahu reports storage of two plants in containers (Pahole 2019).
 - o In 2019, PEPP reported collection of at least 12 fruit representing four founders from the northern Ko'olau mountains. The embryos were excised and in propagation at the Lyon Arboretum Micropropagation Laboratory (PEPP 2019). (USFWS, 2021)

References

U.S. Fish and Wildlife Service. 2015. Endangered and Threatened Wildlife and Plants

Endangered Status for 49 Species From the Hawaiian Islands

Proposed Rule. FR Vol. 80, No. 189. Pages 58820-58909

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2017. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed March 2017.

Proposed Rule. FR Vol. 80, No. 189. Pages 58820-58909.

USFWS. 2016. Endangered and Threatened Wildlife and Plants

Endangered Status for 49 Species From the Hawaiian Islands. Final rule. 81 FR 67786 - 67860 (September 30, 2016). USFWS. 2021. *Pritchardia bakeri* (Baker's loulu) 5-Year Review Summary and Evaluation U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 22 pp.

Endangered Status for 49 Species From the Hawaiian Islands. Final rule. 81 FR 67786 - 67860 (September 30, 2016).

USFWS. 2021. *Pritchardia bakeri* (Baker's loulu) 5-Year Review Summary and Evaluation U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 22 pp.

SPECIES ACCOUNT: *Pritchardia lanigera* (Lo`ulu)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/29/2013; Pacific Region (R1) (USFWS, 2016)

Physical Description

Pritchardia lanigera is a palm tree 7.6 meters (m) (25 feet (ft)) or taller; some at 14 m (45 ft). Variable, smooth grayish trunk 15 to 51 centimeters (cm) (6 to 20 inches (in)) in diameter. The crown contains up to 20 ascending, spreading to drooping leaves, 0.9 to 1.2 m (3 to 4 ft) long and 1.2 to 1.5 m (4 to 5 ft) wide, slightly wavy to nearly flat blades and 0.9 m (3 ft) -long leaf stalks, with a moderate amount of fibers at the base. Blades, glossy above and below, are deeply divided to nearly half into as many as 70 stiff-tipped segments. The spreading to drooping flower stalks have up to three moderately long primary branches, almost equal to leaf stalks in length, with fruit stalks longer than leaf stalks, but shorter than leaf blades. Flower and fruit branchlets are short, thick, and stubby, to 7.6 cm (3 in) long; densely clothed in thick, pinkish brown woolly hairs. Fruit are shiny, black, ellipsoid to spherical, up to 5.6 cm (2.2 in) long and 4 cm (1.6 in) wide when mature (Hodel 2012, pp. 102–104) (USFWS, 2020).

Taxonomy

A member of the palm family (Arecaceae). The genus *Pritchardia* has 28 known species, 14 of which are endemic to the Hawaiian Islands, and its range is restricted to the Pacific archipelagos of Hawaii, Fiji, the Cook Islands, Tonga, and Tuamotus (Chapin et al. 2004, p. 273) (USFWS, 2013).

Historical Range

Historically, *P. lanigera* was known from the Kohala Mountains, Hamakua district, windward slopes of Mauna Kea, and southern slopes of Mauna Loa (Hawaii) (USFWS, 2013).

Current Range

It currently occurs along the windward side of the Kohala Mountains, Kau FR, and TNC Kau Preserve (Hawaii) (USFWS, 2013).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Possibly insect pollinated (USFWS, 2020)

Lifespan

Adult: Long (USFWS, 2023)

Reproduction Narrative

Adult: According to field biologists, pollination rates appear to be low for this species, and the absence of seedlings and juveniles at known locations suggests that regeneration is not occurring, which they believe to be caused, in part by predation (USFWS, 2013). The flowers of *Pritchardia* are hermaphroditic (having male and female parts) and are coriaceous (leathery). Insects are attracted to the pollen and nectar, which are both abundant (MacCaughy 1918, p. 326). According to field biologists, pollination rates appear to be low for this species, and the absence of seedlings and juveniles at known locations suggests that regeneration is not occurring, which they believe to be caused, in part, by beetle, rat, and pig predation on the fruits, seeds, and seedlings (Bio 2011, pers. comm.; Crysdale 2013 in HVNP 2015, pp. 467–468). The establishment of new populations of *Pritchardia* is likely a result of the heavy, hard, and durable fruit being carried by their own weight down steep slopes (MacCaughy 1918, p. 321). The fruit can also be transported in streams and lodge between cracks and crevices where they germinate and grow; it is common to observe *Pritchardia* growing along valley slopes and streams (MacCaughy 1918, p. 321). In addition, young *Pritchardia* are shade tolerant as they grow under the canopy of the wet forest (MacCaughy 1918, p. 321). (USFWS, 2020).

Habitat Type

Adult: Terrestrial (USFWS, 2020)

Habitat Vegetation or Surface Water Classification

Adult: Lowland mesic and wet forest, montane wet forest (USFWS, 2013; NatureServe, 2015)

Environmental Specificity

Adult: From 457 to 1311 m (1500 to 4300 ft) elevation (USFWS, 2020)

Habitat Narrative

Adult: Inhabits wet forests on ridges, gulch sides, or on gentle slopes (NatureServe, 2015). It occurs in the lowland mesic, lowland wet, montane wet, and wet cliff ecosystems (USFWS, 2013). *Pritchardia lanigera* is endemic to island of Hawai'i (Read and Hodel 1990, p. 1371). Historically, *P. lanigera* was known from the Kohala mountains-Hāmākua district and the windward slopes of Mauna Kea (National Park Service (NPS) 2015, pp. 467–468). The species occurs as widely scattered individuals in two disjunct populations in northwest and southern parts of the island (Hodel 2012, p. 104). In 1989, the Department of Land and Natural Resources (DLNR) determined there to be one occurrence (one individual) within Pu'u o Umi Natural Area Reserve (NAR) in uluhe shrubland (DLNR 1989, pp. 10, 12). Subpopulations of *Pritchardia lanigera* near Kaiholena observed in 1980 were not relocated on a survey in 2008 (Wood et al. 2008, p. 6) and were thought to be extirpated. However three small subpopulations (possibly reintroduced plants) were located in 2009 by TNC staff working with local hunters and volunteers (TNC 2011, p.p. 10, 34; NPS 2015, pp. 267–468; HVNP 2019, p. 22). The individuals at 'Āwini in the Kohala mountains were last observed in 1910 while individuals at Honopue were last observed in 1973 (USFWS 2020, unpubl. data). Currently, there are approximately 150 to 200 widely scattered plants in Hāmākua-Pali and Kohala Forest Reserve (FR) with unknown numbers in the Hāmākua FR, Mānowai'ale'e FR and Hilo FR unknown number (likely fewer) of wild individuals in the Ka'ū FR. (Hodel 2012, p. 104) (USFWS, 2020). *Pritchardia lanigera* occurs in a variety of wet to very wet habitats including shrublands, cliffs and ridges, bogs, and forest, from 457 to 1311 m (1500 to 4300 ft) elevation. *Pritchardia lanigera* occurs in grassland-shrubland characterized shrubs and grasses between 1 to 3 m (3 to 10 ft) tall. Associated native species include *Dicranopteris linearis* (uluhe), *Dodonea viscosa* ('a'ali'i), *Leptecophylla*

tameiameaie (pūkiawe), Euphorbia spp. ('akoko), and Bidens spp. (ko'oko'olau) (Ball et al. 2019, p. 4). Cliff and ridge habitat of Pritchardia lanigera is characterized by different species of native shrubs including Dubautia spp., Metrosideros spp. ('ōhi'a), and Cibotium spp. (hāpu'u) (Nelson et al. 2019, p. 3). (USFWS, 2020).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Not available

Number of Populations:

9 (USFWS, 2023)

Population Size:

150-200 (USFWS, 2023)

Population Narrative:

Currently, *P. lanigera* is known from 8 occurrences totaling fewer than 230 individuals (USFWS, 2013). *Pritchardia lanigera* is endemic to island of Hawai'i (Read and Hodel 1990, p. 1371). Historically, *P. lanigera* was known from the Kohala mountains-Hāmākua district and the windward slopes of Mauna Kea (National Park Service (NPS) 2015, pp. 467–468). The species occurs as widely scattered individuals in two disjunct populations in northwest and southern parts of the island (Hodel 2012, p. 104). In 1989, the Department of Land and Natural Resources (DLNR) determined there to be one occurrence (one individual) within Pu'u o Umi Natural Area Reserve (NAR) in uluhe shrubland (DLNR 1989, pp. 10, 12). Subpopulations of *Pritchardia lanigera* near Kaiholena observed in 1980 were not relocated on a survey in 2008 (Wood et al. 2008, p. 6) and were thought to be extirpated. However three small subpopulations (possibly reintroduced plants) were located in 2009 by TNC staff working with local hunters and volunteers (TNC 2011, p.p. 10, 34; NPS 2015, pp. 267–468; HVNP 2019, p. 22). The individuals at 'Āwini in the Kohala mountains were last observed in 1910 while individuals at Honopue were last observed in 1973 (USFWS 2020, unpubl. data). Currently, there are approximately 150 to 200 widely scattered plants in Hāmākua-Pali and Kohala Forest Reserve (FR) with unknown numbers in the Hāmākua FR, Mānowai'ale'e FR and Hilo FR unknown number (likely fewer) of wild individuals in the Ka'ū FR. (Hodel 2012, p. 104) (USFWS, 2020). Number of Populations: 9. Number of Individuals: 150-200 (USFWS, 2023)

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 (pigs, goats, mouflon, and cattle), nonnative plants, 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. The effects of nonnative plants on native plant species include competition and displacement; competition may be for water, light, or nutrients, or it may involve allelopathy (chemical inhibition of other plants). 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: Lack of regeneration (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: Lack of, or low levels of, regeneration (reproduction and recruitment) in the wild has been observed, and is a threat to, *Pritchardia lanigera* (USFWS, 2013).

Stressor: Overutilization (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: The plant species *Pritchardia lanigera* is vulnerable to the impacts of overutilization due to collection for trade or market. Based on the history of collection of endemic Hawaiian *Pritchardia* spp., the market for Hawaiian *Pritchardia* trees and seeds, and the inherent vulnerability of the small populations of *Pritchardia lanigera* to the removal of individuals (seeds), the Services consider collection to pose a serious and ongoing threat to this species (USFWS, 2013).

Stressor: Predation and herbivory (USFWS, 2013)

Exposure:

Response:

Consequence:

Narrative: Predation and herbivory by nonnative animal species (pigs, goats, mouflon, rats, two-spotted leaf-hopper (*Sophonia rufofascia*), and beetles (family Scolytidae, genus *Coccotrypes*)) is considered an ongoing threat to *Pritchardia lanigera* throughout the species range. Non-native animals cause mechanical damage to plants and destruction of plant parts (branches, fruits, and seeds) (USFWS, 2013).

Stressor:

Exposure:

Response:

Consequence:

Narrative:

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan. Recovery priority numbers are assigned to species or subspecies based on the degree of threat, the potential for recovery, and their taxonomic status (i.e., full species vs. subspecies) and range from 1C (highest, "C" indicating the potential for conflict with human economic activities) to 18 (lowest) (USFWS 1983a, 1983b). All of the 15 species have a high degree of threat to their habitat and continued existence (Table 2). These threats are ongoing and include habitat loss and degradation by invasive nonnative plant species, feral ungulates, predation or herbivory by nonnative invertebrates and vertebrates, diseases, climate change, and the stochastic and demographic consequences associated with a low number of individuals and populations. *Pittosporum hawaiiense* and *Pritchardia lanigera* are assigned a recovery priority number of 2 based on a high degree of threat, a high potential for recovery because their threats are well understood and can be alleviated, and because of their status as full species. *Bidens micrantha* ssp. *ctenophylla* is assigned a recovery priority number of 3, based on a high degree of threat, a high potential for recovery because its threats are understood and can be alleviated, and because of its status as a subspecies. *Cyanea marksii*, *Cyanea tritomantha*, *Cyrtandra nanawaleensis*, *Cyrtandra wagneri*, *Drosophila digressa*, *Phyllostegia floribunda*, *Platydesma remyi*, *Schiedea hawaiiensis*, *Stenogyne cranwelliae*, and *Vetericaris chaceorum* are assigned a recovery priority number of 5, based on a high degree of threat, a low potential for recovery due to a small number of individuals and some threats being well understood while others are difficult to mitigate, and because of their status as a species. *Bidens hillebrandiana* ssp. *hillebrandiana* and *Schiedea diffusa* ssp. *macraei* are assigned a recovery priority number of 6, based on a high degree of threat, a low potential for recovery due to a small number of individuals and some threats being well understood while others are difficult to mitigate, and because of their status as subspecies (USFWS, 2019).

Recovery Priority Number: 2

Number of populations: 5. Reproducing numbers of individuals: 200 (USFWS, 2023).

Delisting Criteria:

Not available - this species does not have a recovery plan.

Number of populations: 10. Reproducing numbers of individuals: 200 (USFWS, 2023).

Recovery Actions:

- Not available - this species does not have a recovery plan.
- The Kohala Watershed Partnership (KWP) is constructing a 700-ac (283-ha) fenced enclosure in the Kohala Mountains in an area where individuals of *Pritchardia lanigera* are known. Completion of this fence is expected in 2016 (Ball 2013, pers. comm.; Purell 2013, in litt.). This enclosure will provide protection to individuals of *P. lanigera* from ungulates once the fence is completed and ungulates are removed within the fence. In addition, the KWP plans to control nonnative plants (i.e., *Hedychium gardnerianum* and *Psidium cattleianum*) within the enclosure (Purell 2013, in litt.) (USFWS, 2013).

Conservation Measures and Best Management Practices:

- Current Management Actions:
 - Surveys and monitoring—
 - o The Plant Extinction Prevention Program (PEPP) monitors populations of *Pritchardia lanigera* at Kaiholena and Pu'u O Umi NAR (PEPP 2014, 2018, 2019). Twenty-six immature individuals were discovered on a survey of Kaiholena in 2013 (PEPP 2014). PEPP estimated at least two populations on the island of Hawai'i totaled 150 mature plants (PEPP 2014).
 - o In 2011, on a survey of Kaiholena (Ka'u), TNC discovered an additional previously outplanted individual of *Pritchardia lanigera* (TNC 2011, pp. 10, 34).
 - Feral ungulate control—
 - o Two populations are fenced within the Pu'u O Umi NAR (USFWS 2020, unpubl. data).
 - o TNC has fenced the Kaiholena Unit at Ka'u Preserve (TNC 2011, p. A4).
 - Control of established ecosystem-altering invasive plants—TNC prioritizes and manages invasive plants at Ka'u Preserve (TNC 2011, p. A5).
 - Captive propagation for genetic storage and reintroduction—
 - o In 2017, the Volcano Rare Plant Facility (VRPF) reported 50 plants in inventory representing six founders from Kohala; and in 2019 an additional 39 individuals representing five more founders from Kohala (VRPF 2017-2019). A total of 22 founders have been propagated for outplanting. Currently, there are 40 plants representing six founders in inventory (VRPF 2019).
 - o In 2011, at Kaiholena (Ka'u), TNC placed netting under trees and conducted seed collection. Seeds were sent to VRPF to propagate for reintroduction (TNC 2011, pp. 10, 34).
 - o PEPP collected from at least 50 percent of the known populations, but less than 1 percent of the individuals for storage and propagation (PEPP 2014).
 - Reintroduction—
 - o Between 2017 and 2019, VRPF reported reintroduction of a total of 101 plants representing 22 founders: 21 plants representing one founder from Ka'u-Kaiholena and 20 founders from Kohala in 2017, and 84 plants representing 12 founders at Kohala were reintroduced in 2019 (VRPF 2013-2019).
 - o In 2011, HVNP reintroduced 22 individuals to the Kahuku Paddock #2 (HVNP 2019, p. 22). One year post planting 95 percent had survived. Unfortunately since that time the protective ungulate proof fences deteriorated and some of the plants were damaged by feral pigs. In 2014, the fence was repaired and one additional plant was reintroduced. Three years post planting (March 2014) 12 were alive (57 percent). No activity was conducted from 2015 to 2018. Monitoring was conducted in 2019 at the planting site in lower Kahuku paddocks. At least nine are surviving and are growing vigorously; however, no fruiting or recruitment has been observed (HVNP 2019, p. 22; HVNP 2020).
 - o Reintroductions by TNC in 2008 showed a survival rate of 92 percent by 2010 (TNC 2011, pp. 10, 34).
 - o The National Tropical Botanical Garden (NTBG) reported planting two individuals representing two founders from Kohala-Waimanu Rim as a living collection in Southshore Gardens (NTBG 2019).
 - o PEPP reported seven individuals reintroduced at Pu'u O Umi NAR-Palikai (PEPP 2018, 2019). (USFWS, 2020).

References

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://explorer.natureserve.org>. (Accessed: September 15, 2016)

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS 2013. Endangered and Threatened Wildlife and Plants

Determination of Endangered Species Status for 15 Species on Hawaii Island

Final Rule. 78 Federal Register 209. October 29, 2013. Pages 64637 - 64690. USFWS. 2020. *Pritchardia lanigera* (Ioulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service.

Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 27 pp.

Final Rule. 78 Federal Register 209. October 29, 2013. Pages 64637 - 64690

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://explorer.natureserve.org>. (Accessed: September 15, 2016). USFWS. 2020. *Pritchardia lanigera* (loulou) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 27 pp. USFWS. 2020. *Pritchardia lanigera* (loulou) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 27 pp. USFWS. 2023. Recovery Plan for 15 Species from the Island of Hawai'i. Portland, Oregon. xiii + 87 pp.

Final Rule. 78 Federal Register 209. October 29, 2013. Pages 64637 - 64690. USFWS. 2020. *Pritchardia lanigera* (loulou) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 27 pp. USFWS. 2023. Recovery Plan for 15 Species from the Island of Hawai'i. Portland, Oregon. xiii + 87 pp.

USFWS. 2013. Endangered and Threatened Wildlife and Plants

Final Rule. 78 Federal Register 209. October 29, 2013. Pages 64637 - 64690.

U.S. Fish and Wildlife Service. 2019. Recovery Outline for Hawai'i Island. 25 pp.

USFWS. 2023. Recovery Plan for 15 Species from the Island of Hawai'i. Portland, Oregon. xiii + 87 pp.

USFWS. 2020. *Pritchardia lanigera* (loulou) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 27 pp.

SPECIES ACCOUNT: *Pritchardia maideniana* (= *P. affinis*) (Lo`ulu)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/04/1994; Pacific Region (R1) (USFWS, 2016)

Physical Description

A fan palm 10-25 m tall. Wedge-shaped leaves have a pale-colored or pinkish soft wool.
(NatureServe, 2015)

Taxonomy

The genus is restricted to tropical pacific islands, this species is endemic to island of Hawaii. Hodel (2007) found no differences between *Pritchardia affinis* and *P. maideniana*; "Because *P. affinis* was the more recently described, Hodel (2007) reassigned the species to *P. maideniana*" (USFWS 2015) (NatureServe, 2015).

Historical Range

Historically known from the Kohala Mountains and along the southeastern coast of the Big Island (NatureServe, 2015). Its original geographical range on the island of Hawaii is believed to have been along dry coastal areas from Kalapana to Punaluu and the Kailua district of Kona, where at one time they occurred abundantly (Gemmill 1996; Bezona 2010) (USFWS, 2012).

Current Range

Currently known from the western coast of the Big Island (NatureServe, 2015). It is found in Puna, Kona, and Kau on the island of Hawaii (USFWS, 2012).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Lifespan

Adult: > 10 years (USFWS, 2012)

Reproduction Narrative

Adult: It is a long-lived perennial (USFWS, 2012).

Habitat Type

Adult: Terrestrial (USFWS, 2012)

Habitat Vegetation or Surface Water Classification

Adult: Coastal mesic forest (USFWS, 1996)

Geographic or Habitat Restraints or Barriers

Adult: 0 - 1,969 ft. elevation (USFWS, 2012)

Habitat Narrative

Adult: *Pritchardia affinis* is typically found from sea level to around 600 meters (0 to 1,969 feet) in leeward coastal sites and inland gulches (Wagner et al. 1999). At the time of listing (USFWS 1994) and thereafter, most individuals of *P. affinis* were found in areas of human habitation or development. Because all native vegetation in the known geographical range of *P. affinis* has been cleared, it is uncertain what the original associated native plant species were (USFWS 1996) (USFWS, 2012). The habitat of *Pritchardia affinis* is coastal mesic forest on the leeward side of the Big Island, possibly near or in brackish water (USFWS, 1996).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Not available

Species Trends:

Decline in number of populations (USFWS,2012)

Number of Populations:

4 (USFWS, 2012)

Population Size:

~9 mature and 80 immature wild (USFWS, 2020)

Population Narrative:

At the time of listing (USFWS 1994) and when the recovery plan was written (USFWS 1996), approximately 50 to 65 individuals were thought to exist within 8 or more populations. The most current estimate is a total of more than 50 individuals occurring in 4 populations reported for fiscal years 2009 and 2010 (Plant Extinction Prevention Program 2009, 2010). There are approximately 76 outplanted individuals (USFWS, 2012). Currently, nine mature and approximately 80 immature wild individuals of *Pritchardia maideniana* occur at seven locations on the island of Hawai'i. A landscape-based assessment of climate change vulnerability for native plants of Hawai'i using high resolution climate change projections was made by Fortini et al. (2013) and their analysis showed that *P. maideniana* is vulnerable to the effects of climate change. Seed and cuttings collections from wild and reintroduced individuals, propagation, and reintroduction are ongoing. Research on optimal seed storage techniques is ongoing. Approximately 180 individuals have been reintroduced since the last 5-year review with variable or unknown success. Recruitment of seedlings has been reported at one location. The introduction of the nonnative coconut rhinoceros beetle to O'ahu poses a threat to this species if the beetle is transported to the island of Hawai'i. (USFWS, 2020)

Threats and Stressors

Stressor: Development (NatureServe, 2015)

Exposure:**Response:****Consequence:**

Narrative: This species is threatened by coastal development (NatureServe, 2015). By the mid-19th century, land reform laws “provided the impetus for rampant clearing of upland forests” (Culliney 1988). Large-scale commercial ventures began to develop in agriculture, logging, and cattle production. The direct loss of individual plants, loss of habitat, introduction and establishment of alien plants, and introduction of ungulates and other non-native animals are all a legacy of this time (USFWS, 1996).

Stressor: Invasive plants (USFWS, 2012)

Exposure:**Response:****Consequence:**

Narrative: The introductions of more than 800 alien plant taxa presently in Hawaii have brought aggressive, vigorous competitors that are displacing native plant populations. The following principal weeds appear to be exceptionally invasive and/or disruptive to native ecosystems: Pennisetum clandestinum (kikuyu grass); Pennisetum setaceum (fountain grass); Andropogon virginicus (broomsedge or yellow bluestem); Digitaria ciliaris (Henry’s crabgrass, kukaepuaa); Oplismenus hirtellus (basketgrass, honohono kukui, honohono maoli); Metastachys azedarach (China berry, pride of India, inia, ilinia); Leucaena leucocephala (koa haole, ekoa, lilikoa); Schinus terebinthifolius (Christmas berry, wilelaiki, naniohilo); Lantana camara (lantana, lakana, laau kalakala, lanakana, mikinolia hihiu, mikinolia hohono, mikinolia kuku); Polygonum persicaria (watersmart); Ardisia cuneata (shoebutton ardisia); Casuarina spp. (ironwood); Hebe pectinata (telegraph weed); and Cannabis sativa (marijuana) (USFWS, 1996).

Stressor: Stochastic events (USFWS, 2012)

Exposure:**Response:****Consequence:**

Narrative: Lava flows from Kilauea destroyed several individuals in 1989 (USFWS 1996), and volcanic tree molds suggest that individuals of *P. affinis* may have perished in earlier flows (Woodcock and Kalodimos 2005). Wind damage is also a threat (USFWS, 2012). Today, fires are mainly human caused. The effects on vegetation are usually deleterious (Cuddihy and Stone 1990). Native plants and dormant seeds in the seed bank are killed by hot fires while fountain grass resprouts quickly at the base, again forming dense clumps and readily producing seeds. On the Island of Hawaii, vegetation on the dry slopes of Mauna Kea is particularly vulnerable (USFWS, 1996).

Stressor: Collection (USFWS, 2012)

Exposure:**Response:****Consequence:**

Narrative: Not available

Stressor: Predation/herbivory (USFWS, 2012)

Exposure:**Response:**

Consequence:

Narrative: Feral pigs (*Sus scrofa*) root and destroy seedlings, which prevents regeneration (USFWS 1994, 1996, 2003). Nelson and Wright (2005) reported on the damage caused to species of *Pritchardia* in Hawaii by the banana moth (*Opogona sacchari*), the females of which lay eggs in wounded or otherwise compromised tissues of *Pritchardia*. However, no mention was made of known damage to *P. affinis* by the moths (Nelson and Wright 2005) (USFWS, 2012). Rats are known to eat *Pritchardia* fruits (NatureServe, 2015).

Stressor: Climate change (USFWS, 2012)

Exposure:

Response:

Consequence:

Narrative: Climate change may pose a threat to this species. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species (USFWS, 2012).

Recovery**Reclassification Criteria:**

1. A total of five to seven populations should be documented on the Big Island (USFWS, 1996).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population (for long-lived perennials) (USFWS, 1996).
3. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered (USFWS, 2012).

Delisting Criteria:

1. A total of 8 to 10 populations of each taxon should be documented on the Big Island (USFWS, 1996).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population (for long-lived perennials) (USFWS, 2012).
3. Each population should persist at this level for a minimum of 5 consecutive years (USFWS, 2012).

Recovery Actions:

- Protect current populations and manage threats (USFWS, 1996).
- Conduct essential research (USFWS, 1996).
- Expand existing wild populations, as necessary (USFWS, 1996).
- Create new populations within historical range, as necessary (USFWS, 1996).
- Evaluate and validate recovery objectives (USFWS, 1996).
- Protection from development, pigs and rats is necessary (USFWS, 1996).
- The rare natural habitat of this species should be protected (USFWS, 1996).

- Propagation and maintenance of ex situ genetic stock should continue. Outplanting of propagated plants will likely be necessary in order to augment populations (USFWS, 1996).
- Efforts to prevent spread of lethal yellow to Hawaii should continue (USFWS, 1996).
- Captive propagation for genetic storage and reintroduction: Continue to collect seeds from all existing populations and send to at least two or three different venues for propagation. Additional cultivation is needed ex situ to increase the number of individuals available for reintroductions (USFWS, 2012).
- Reintroduction / translocation site identification: Any remaining natural habitat should be given high priority for protected status. Identify areas within the historical range of the species that are managed for threats (USFWS, 2012).
- Reintroduction / translocation implementation: Continue to reintroduce the species back into its known historical range. Reintroduce at least 20 to 30 individuals in 10 areas to mimic natural populations in areas where survival is deemed likely (USFWS, 2012).
- Predator / herbivore control – Control rodents around all existing populations (USFWS, 2012).
- Ecosystem-altering invasive plant species control – Control invasive introduced plant species around all populations (USFWS, 2012).
- Ungulate exclosures – Construct exclosure fences around all living individuals in the wild and newly established “populations” based on reintroduction activities (USFWS, 2012).
- Ungulate control – Implement ungulate control to protect all populations against disturbances from feral ungulates (USFWS, 2012).
- Site / area / habitat protection – Develop and implement effective measures to reduce the impacts of agricultural and urban development, wind damage, and lava flow (USFWS, 2012).
- Surveys / inventories – Resurvey the historical range of the species to determine if previously unknown or newly reestablished populations exist (USFWS, 2012).
- Threats research: Develop and implement effective measures to reduce the impact of collection. Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species (USFWS, 2012).
- Biosecurity legislation – The State of Hawaii should enact serious measures to keep yellow lethal disease out of the state for the benefit of all palm species, including *P. affinis* (USFWS, 2012).
- Fire protection – Develop and implement a fire management plan for all populations (USFWS, 2012).
- Habitat requirements research – Carry out greenhouse studies that test whether seedlings are able to survive or thrive in brackish habitats, as suggested by some field observations (USFWS, 2012).
- Alliance and partnership development – Work with the National Park Service, Hawaii Division of Forestry and Wildlife, and other land managers to continue implementation of ecosystem-level restoration and management to benefit this species (USFWS, 2012).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: The introduction of the coconut rhinoceros beetle to O’ahu is a potential threat should it be transported to the island of Hawai’i; however, we are not aware of any significant new information regarding the species’ biological status since the last 5-year review in 2012. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2020. • Surveys and inventories—Continue to conduct thorough surveys of all historical and suitable habitat for new occurrences. • Established ecosystem-altering invasive plant monitoring

and control— Control established ecosystem-altering nonnative invasive plant species, and those that compete with *P. maideniana* at all populations. • Drought protection—Determine best reintroduction sites to reduce the impacts of drought. • Fire protection— o Implement fire management plans for HVNP. o Develop fire management plans for other wild and reintroduced populations of *P. maideniana*. • Climate change adaptation strategy—Assess the modeled effects of climate change on this species and use to determine future landscape needed for the recovery of the species. • Predation and herbivore control— o Implement effective control methods for rodents at all wild and reintroduced populations. o Implement effective control methods for the coconut rhinoceros beetle if this invertebrate is transported to the island of Hawai'i. o Construct exclosures at wild and reintroduced populations to prevent seedling predation by feral pigs and other ungulates. • Captive propagation for genetic storage and reintroduction— o Continue collection and propagation efforts for maintenance of genetic stock and for reintroduction. o Increase the number of propagules for reintroductions. o Continue to utilize at least three different facilities for seed storage and propagation. • Reintroduction and translocation— o Determine optimal sites reintroduction and recruitment success and continue to reintroduce individuals into these areas that are managed for known threats, including urban and agricultural development. o Select reintroduction areas with least exposure to strong winds and lava flows. • Biosecurity legislation— o Develop and enforce effective regulations to prevent vandalism and collection. o Develop and enforce effective regulations to prevent deleterious effects of yellow lethal disease facilitated by the banana moth. o Develop and enforce effective regulations to prevent predation and habitat destruction by feral ungulates. o Develop and enforce effective regulations to prevent transport of the coconut rhinoceros beetle to the island of Hawai'i. • Population biology research—Continue seed storage techniques investigations. • Climate change adaptation strategy—Assess the modeled effects of climate change on this species and use to determine future landscape needed for its recovery. • Federal Register updates—Update 50 CFR 17 to reflect the revised taxonomy. • Alliance and partnership development—Continue to work with the Hawai'i Division of Forestry and Wildlife, Hawai'i Volcanoes National Park, and other partners and land managers in planning and implementation of ecosystem-level restoration and management to benefit this species. (USFWS, 2020)

- New Management Actions: • Surveys and inventories—PEPP continues to survey and monitor populations of *Pritchardia maideniana* (PEPP 2017, 2018). • Ecosystem-altering nonnative plant control—PEPP placed weed control mat at one location (PEPP 2018). • Captive propagation for genetic storage and reintroduction— o Between 2013 and 2019, the Volcano Rare Plant Facility (VRPF) reported propagation of 560 plants representing nine founders from five locations. Currently, there is only one plant in refugia (VRPF 2013-2019). o In 2019, Lyon Arboretum reported storage of 3 explants representing one wild individual at Keālia (South Kona) (Lyon Arboretum 2019). o In 2019, the National Tropical Botanical Garden (NTBG) reported 55 plants (representing at least seven individuals at seven locations) in a living collection at the Southshore Garden and three plants (representing an unknown number of individuals) in a living collection at Kahanu (NTBG 2019). • Reintroduction and translocation— o In 2019, Hawai'i Volcanoes National Park (HVNP) reported that seven years post-planting of 59 plants at Keauhou Landing in 2008, two individuals survive (HVNP 2019a, p. 20; HVNP 2019b; HVNP 2020). No activity was conducted between 2016 and 2019. o PEPP provided a summary of current reintroductions of *P. maideniana* totaling 87 individuals at five locations (PEPP 2019). o From 2013 to 2019, the VRPF reintroduced 120 plants to Manukā and Kiolaka'a representing five founders from two locations, 78 plants representing five founders from two locations were sent to Future Forests Nursery (VRPF 2013-2019). Survival is unknown. • Seed storage research—A study by Walters (2015, in litt.) was conducted to determine optimal seed bank storage methods for Hawaiian plants including the palm species *Pritchardia remota* and *P. aylmeri*.

robinsonii. The results of this study may also apply to *Pritchardia maideniana*. The highest viability after stress challenges were achieved from embryos excised from fruits that are dark brown (older and drier) rather than green. Coloration of maturing fruits appears to be linked to the water content of the embryo, a measure of maturity in freshly harvested fruits. Embryos with more water are less likely to survive freezing temperatures associated with preparation for storage. Embryos kept within whole fruits can survive the initial stress of freezing if methods used for drying and use of liquid nitrogen are optimal, with 80 to 100 percent viability. Embryos are excised from larger fruits for better temperature control. In addition, removal of embryos saves on the storage space required and maintenance costs. Studies using fruit from *P. hillebrandia* are ongoing (USFWS, 2020).

References

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

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS. 2012. *Pritchardia affinis* (Loulu)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

USFWS 2012. *Pritchardia affinis* (Loulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii

U.S. Fish and Wildlife Service. 1996. Big Island Plant Cluster Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR. 202+ pp.

USFWS 2012. *Pritchardia affinis* (Loulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. USFWS. 2020. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Pritchardia affinis* (loulu). 11 pp.

USFWS. 2012. *Pritchardia affinis* (Loulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

USFWS. 2012. *Pritchardia affinis* (Loulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

USFWS 2012. *Pritchardia affinis* (Loulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii.

USFWS. 2020. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Pritchardia affinis* (loulu). 11 pp.

SPECIES ACCOUNT: *Pritchardia napaliensis* (Lo`ulu)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/10/1996; Pacific Region (R1) (USFWS, 2016)

Physical Description

A fan palm 4-6 m tall, with slender trunk (NatureServe, 2015). A small tree with about 20 leaves and an open crown. This species is distinguished from others of the genus that grow on Kauai by having about 20 flat leaves with pale scales on the lower surface that fall off with age, inflorescences with hairless main axes, and globose round fruits less than 3 cm (1.2 in) long (Read and Hodel 1999) (USFWS, 2003).

Taxonomy

A member of the palm family (Arecaceae) (USFWS, 2003). Place holder for the taxon in Kartesz Checklist (1994) and Synthesis (1999) as "P. remota ssp. napaliensis (St. John) R.W. Read, comb. nov. ined." The USFWS and HIHP track as P. napaliensis. Endemic on Kauai. The subspecies combination is not in the International Plant Name Index as of June 2006 (NatureServe, 2015).

Historical Range

See current range/distribution.

Current Range

It is known from State-owned land in Pohakuao, Alealau, Waiahuakua, and Hoolulu Valley within the Hono o Na Pali NAR and Na Pali Coast State Park (GDSI 2000; HINHP Database 2000; K. Wood, in litt. 1999) (USFWS, 2003). Island Distribution: Found on Kauai (USFWS, 2021c)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Lifespan

Adult: > 10 years

Breeding Season

Adult: Unknown (USFWS, 2003)

Key Resources Needed for Breeding

Adult: Unknown (USFWS, 2003)

Reproduction Narrative

Adult: It is a long-lived perennial (USFWS, 2010). Its flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown (Service 1998a) (USFWS, 2003).

Habitat Type

Adult: Terrestrial (USFWS, 2003)

Habitat Vegetation or Surface Water Classification

Adult: Lowland dry to diverse mesic forest, montane wet forest (USFWS, 2003)

Geographic or Habitat Restraints or Barriers

Adult: 500 - 3,800 ft. elevation (USFWS, 2010)

Environmental Specificity

Adult: Broad (inferred from USFWS, 2010)

Habitat Narrative

Adult: Pritchardia napaliensis typically grows at a wide variation of elevations between 152 and 1,158 meters (500 and 3,800 feet) in a wide variety of habitats (USFWS 1998, 2003; 2010). Habitats range from lowland dry to diverse mesic forests dominated by Diospyros spp. or montane wet forests dominated by Metrosideros polymorpha and Dicranopteris linearis (USFWS, 2003).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Not available

Species Trends:

Increasing (USFWS, 2010)

Number of Populations:

6 (USFWS, 2022)

Population Size:

~255 (USFWS, 2022)

Population Narrative:

In 1996, when the species was listed and in 1998, when the recovery plan for the species was written, USFWS knew of three populations of Pritchardia napaliensis totaling no more than 90 individuals (USFWS 1996, 1998). Pritchardia napaliensis is currently known to have only 157 individuals occurring in three isolated valleys along the Na Pali Coast. Since 1989, 73 individual trees of Pritchardia napaliensis survive from the approximately 250 planted for genetic storage in National Tropical Botanical Gardens on Kauai (USFWS, 2010). Pritchardia napaliensis has only been known from five occurrences (USFWS, 2003). New Status Information: In addition to those populations cited in the previous 5-year review, new observations include the following: • At the time of the last 5-year review in 2010 there were four populations totaling 157 to 160

individuals on Kauai. Surveys conducted after the last 5-year review have confirmed approximately 110 individuals in the same locations at Pohakuao (30), Hanakoa (one), Waiahuakua (two), Pohakea (ca 50), Hoolulu (27), and lower Limahuli Valley (unknown) (Hodel 2012; NTBG 2010, 2011; PEPP 2010, 2011). The current status of two individuals at Alaealau is unknown (USFWS, 2017). At the time of the last 5-year review in 2017 there were four populations totaling approximately 110 individuals on Kaua'i (USFWS 2017). Currently, there are 6 populations with an estimated 255 individuals, the largest population with 75 individuals (Walsh et. al. 2021). Recent monitoring conducted by the National Tropical Botanical Garden (NTBG) confirmed one healthy tree in each of two populations located in Hono a Na Pali Natural Area Reserve (USFWS, 2022).

Threats and Stressors

Stressor: Feral ungulates (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Habitat degradation and grazing by feral goats (*Capra hircus*) and pigs (*Sus scrofa*). Goats graze (Factor C) and pigs uproot seedlings in Hoolulu (USFWS, 2010).

Stressor: Rats (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: Seed predation by rats (*Rattus rattus*) (USFWS, 2010).

Stressor: Invasive plants (USFWS, 2010)

Exposure:

Response:

Consequence:

Narrative: In Hoolulu, threats are competition with invasive introduced plant species including *Aleurites moluccana* (kukui), *Bryophyllum pinnatum* (airplant), *Christella dentata* (downy wood fern), *Clidemia hirta* (Koster's curse), *Cordyline fruticosa* (ti), *Elephantopus mollis* (elephant's foot, tobacco weed), *Oplismenus hirtellus* (basketgrass), *Pluchea carolinensis* (sourbush), *Psidium guajava* (common guava), *Lantana camara* (lantana), *Melinis minutiflora* (molasses grass), *Rubus rosifolius* (thimbleberry), and *Schefflera actinophylla* (octopus tree) (Tangalin 2009; Wood 2009). In Pohakuao, invasive introduced plant species are *Bryophyllum pinnatum*, *Erigeron karvinskianus* (daisy fleabane), *Lantana camara*, and *Pluchea carolinensis* (National Tropical Botanical Garden 2008a). Lower Limahuli's invasive introduced plant species include *Andropogon virginicus* (broomsedge), *Blechnum appendiculatum* (NCN), *Bryophyllum pinnatum*, *Clidemia hirta*, *Clusia rosea* (autograph tree), *Erigeron karvinskianus*, *Lantana camara*, *Nephrolepis falcata* (fishtail fern), *Pluchea* sp., *Psidium guajava*, and *Rubus rosifolius* (Tangalin 2009). Hanakapiai's invasive introduced plant species are *Aleurites moluccana*, *Bryophyllum pinnatum*, *Lantana camara*, *Psidium guajava*, and *Setaria parviflora* (yellow foxtail) (National Tropical Botanical Garden 2008b) (USFWS, 2010).

Stressor: Collection and vandalism (USFWS, 2010)

Exposure:

Response:**Consequence:**

Narrative: Theft of plants and seeds by avid palm collectors is a threat. The species is also threatened by vandalism (Factor E). In 1993, the fence surrounding 39 recently planted *Pritchardia napaliensis* on Kauai was vandalized and those plants were stolen (USFWS 2003; 2010).

Stressor: Small population size (USFWS, 2003)

Exposure:**Response:****Consequence:**

Narrative: Because of the small number of remaining populations and individuals, this species is susceptible to a risk of extinction from naturally occurring events, such as landslides or hurricanes, and from reduced reproductive vigor (61 FR 53070; Craig Koga, DOFAW, in litt. 1999; A. Kyono, pers. comm., 2000) (USFWS, 2003).

Stressor: Climate change loss or degradation of habitat

Exposure:**Response:****Consequence:**

Narrative: Climate change may pose a threat to this species. Fortini et al. (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawaii using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. The assessment by Fortini et al. (2013) concluded that *Pritchardia napaliensis* is extremely vulnerable to the impacts of climate change, with a vulnerability score of 0.89 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). Therefore, additional management actions are needed to conserve this taxon into the future (USFWS, 2017).

Stressor: Hurricanes—Loss and degradation of habitat

Exposure:**Response:****Consequence:**

Narrative: —Loss and degradation of habitat—Hurricanes were omitted in the last five year review. In November 1982, Hurricane Iwa struck the Hawaiian Islands, with wind gusts exceeding 100 miles per hour (mph) (161 kilometers per hour (kph)), causing extensive damage, especially on the islands of Niihau, Kauai, and Oahu (Businger 1998). In September 1992, Hurricane Iniki, a category 4 hurricane with maximum sustained wind speeds recorded at 140 mph (225 kph), passed directly over the island of Kauai. Many forest trees were destroyed (Perlman 1992), which opened the canopy and facilitated the invasion of nonnative plants (Kitayama and Mueller-Dombois 1995). A destructive hurricane holds the potential of driving a localized endemic species to extinction in a single event, and 70 percent of all listed plant species on Kauai are only found on Kauai. Hurricanes pose an ongoing and ever-present threat because they can happen at any time, although their occurrence is not predictable. Tropical cyclone frequency and intensity are projected to change as a result of climate change over the next 100 to 200 years (Vecchi and Soden 2007; Emanuel et al. 2008; Yu et al. 2010). In the central Pacific, modeling projects an increase of up to two additional tropical cyclones per year in the main Hawaiian Islands by 2100 (Murakami et al. 2013) (USFWS, 2017).

Stressor: Landslides and invasive grasses (USFWS, 2022)

Exposure:

Response:

Consequence:

Narrative: This species is vulnerable to landslides, as well as direct competition from nonnative species such as *Ageratina riparia*, *Ageratum conyzoides*, *Andropogon glomeratus*, *A. virginicus*, *Axonopus fissifolius*, *Buddleia asiatica*, *Clidemia hirta*, *Cyperus meyenianus*, *Ehrharta stipoides*, *Erechtites valerianifolia*, *Erigeron karvinskianus*, *Hedychium gardnerianum*, *Kalanchoe pinnata*, *Lantana camara*, *Melinis minutiflora*, *Paspalum conjugatum*, *Rubus argutus*, *R. rosifolius*, *Sacciolepis indica*, and *Sphaeropteris cooperi* (USFWS, 2022).

Recovery

Reclassification Criteria:

1. A total of five to seven populations should be documented on Kauai and at least one other island where they now occur or occurred historically (USFWS, 1998).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population for short-lived perennials (USFWS, 1998).
3. Each population should persist at this level for a minimum of five consecutive years before downlisting is considered (USFWS, 1998).

Number of populations and individuals needed to meet Preventing Extinction Stage based on population and life history characteristics. Number of Populations 3. Mature Individuals per Population 25. (USFWS, 2021c) Number of populations and individuals needed to meet Interim Stage based on population and life history characteristics. Number of Populations 3. Mature Individuals per Population 100. (USFWS, 2021c) Number of populations and individuals needed for Downlisting based on population and life history characteristics. Number of Populations 10. Mature Individuals per Population 200. (USFWS, 2021c)

Recovery Priority Number: 5

Delisting Criteria:

1. A total of eight to ten populations should be documented on Kauai and at least one other island where they now occur or occurred historically (USFWS, 1998).
2. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 300 mature individuals per population for short-lived perennials (USFWS, 1998).
3. Each population should persist at this level for a minimum of five consecutive years before downlisting is considered (USFWS, 1998).

Number of populations and individuals needed for delisting based on population and life history characteristics. Number of Populations 10. Mature Individuals per Population 200. (USFWS,

2021c)

Recovery Actions:

- Protect current populations, control threats and monitor (USFWS, 1998).
- Expand current populations (USFWS, 1998).
- Conduct research essential to conservation of the species (USFWS, 1998).
- Establish new populations as needed to reach recovery objectives (USFWS, 1998).
- Validate and revise recovery objectives (USFWS, 1998).
- Devise and implement a public education program (USFWS, 1998).
- Remove alien plants inside completed enclosure (USFWS, 1998).
- Reduce threats from rodent predation (USFWS, 1998).
- Maintenance of adequate genetic stock (USFWS, 1998).
- Control ungulates and invasive introduced plants in the existing wild populations (USFWS, 2010).
- Continue to collect material for genetic storage and propagation for reintroduction (USFWS, 2010).
- Augment wild populations (USFWS, 2010).
- Assess potential sites for establishing reintroductions (USFWS, 2010).
- Determine suitable methods and implement rat control (USFWS, 2010).
- Work with Hawaii Division of Forestry and Wildlife to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species (USFWS, 2010).
- New Management Actions: • NTBG has collected hundreds of seeds for propagation from populations of *Pritchardia napaliensis* at Hoolulu, upper Limahuli Valley, Waiahuakua, Pohakuao, and Wahiawa from 1989 to 2014. These collections are represented on the Garden's grounds from collections from a few individuals, some which were collected several times, and some collections from an unknown number of founders (NTBG 2017). Seeds of species of *Pritchardia* cannot be stored conventionally, and currently can only be stored for a few months unless they are stored via cryopreservation methods (Walters 2017, pers. comm.). Waimea Valley Arboretum has five individuals in a living collection (Waimea Arboretum 2017). The Kokee Rare Plant Facility has 30 plants from 145 seeds received from six founders from the Hoolulu population (DOFAW 2016). • NTBG collected plant materials for genetic analysis (NTBG 2017) (USFWS, 2017).
- Recommendations for Future Actions: No new threats and no other significant new information regarding the species' biological status have been reported since the last 5-year review in 2010. Therefore, the following recommendations for future actions are reiterated for the 5-year review for 2017. • Surveys and inventories—Survey for populations of *Pritchardia napaliensis* in areas of potentially suitable habitat. • Ungulate monitoring and control—Continue fencing to exclude feral ungulates. Protect all populations against browsing and disturbances from ungulates. • Invasive plant monitoring and control— o Control established ecosystem-altering nonnative invasive plant species around all populations. o Control invasive nonnative species that compete with the species around all populations. • Predator and herbivore monitoring and control—Implement effective measures to control rodents around all known populations. • Predator and herbivore control research—Study *Pritchardia napaliensis* populations to determine level of threat from invertebrate herbivory by the banana moth and any additional needed recovery actions. • Captive propagation for genetic storage and reintroduction—Continue to collect

material for genetic storage. • Reintroduction and translocation— o Assess potential sites for establishing reintroductions. o Continue to reintroduce individuals into suitable habitat within historic range that is being managed for known threats to this species. • Human interaction monitoring and management—Develop and implement effective measures to reduce the threat of collecting. • Population biology research—Study *Pritchardia napaliensis* populations to determine viable population size and structure, geographical distribution, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, limiting factors, and threats (USFWS, 2017).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: No significant new information regarding the species' biological status has been reported since the last 5-year review in 2017, however, new threats have been identified. Therefore, the following recommendations for future actions are new, reiterated, or updated for the 5-year review for 2022. • Surveys and inventories— o Survey for populations of *Pritchardia napaliensis* in areas of potentially suitable habitat. o Determine if historical population is extirpated. o Determine sites that have the highest likelihood of maintaining reintroductions. • Ungulate monitoring and control—Protect all occurrences against browsing and disturbances from feral ungulates. Construct and maintain fenced exclosures around existing populations to prevent imminent extinction. • Invasive nonnative plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species, and those that compete with *P. napaliensis*. • Human interaction monitoring and management—Develop and implement effective measures to reduce the threat of collecting. • Site and habitat protection—Develop and implement effective control measures to reduce the impact of ungulates. • Predator and herbivore monitoring and control—Determine and implement effective control methods for rodents. • Fire prevention and control—Continue to develop and implement fire prevention management plans. • Climate change adaptation strategy—Research suitability of habitat for reintroduction of this species in the future due to the impacts of climate change, including landslides. • Captive propagation for genetic storage and reintroduction—Establish collection and propagation efforts for maintenance of genetic stock and for reintroduction. • Reintroduction and translocation—Reintroduce individuals into suitable habitat within historic range that is being managed for known threats to this species to build resiliency and redundancy to reduce impacts of stochastic events. • Population biology research— o Determine which species may act as pollinators and which may assist with fruit dispersal. o Conduct genetic studies to determine genetic variation within the population and plan an effective breeding program. • Alliance and partnership development—Continue to work with partners and other land managers in planning and implementation of ecosystem-level restoration and management to benefit this species (USFWS, 2022).

References

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS 2003. Endangered and Threatened Wildlife and Plants

Final Designation or Nondesignation of Critical Habitat for 95 Plant Species From the Islands of Kauai and Niihau, HI. 68 Federal Register 39. Pages 9116 - 9164. USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp.

USFWS 2010. *Pritchardia napaliensis* (loulou palm) 5-Year Review Short Form Summary. Region 1/Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

Final Designation or Nondesignation of Critical Habitat for 95 Plant Species From the Islands of Kauai and Niihau, HI. 68 Federal Register 39. Pages 9116 - 9164.

Final Designation or Nondesignation of Critical Habitat for 95 Plant Species From the Islands of Kauai and Niihau, HI. 68 Federal Register 39. Pages 9116 - 9164. USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp. USFWS. 2022. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Pritchardia napaliensis* (Loulou). Interior Region 12/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawai'i. 9 pages.

USFWS. 2010. *Pritchardia napaliensis* (loulou palm) 5-Year Review Short Form Summary. Region 1/Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

USFWS. 2003. Endangered and Threatened Wildlife and Plants

U.S. Fish and Wildlife Service. 2017. 5-YEAR REVIEW. Short Form Summary. Species Reviewed: *Pritchardia napaliensis* (Loulou).

USFWS. 2022. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Pritchardia napaliensis* (Loulou). Interior Region 12/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawai'i. 9 pages.

U.S. Fish and Wildlife Service. 1998. Kauai II: Addendum to the Recovery Plan for the Kauai Plant Custer. U.S. Fish and Wildlife Service, Portland, OR. 84+pp.

USFWS 2010. *Pritchardia napaliensis* (loulou palm) 5-Year Review Short Form Summary. Region 1/Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

USFWS. 2021c. Kauai Islandwide Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. 109 pp.

SPECIES ACCOUNT: *Pritchardia remota* (Lo`ulu)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/21/1996; Pacific Region (R1) (USFWS, 2016)

Physical Description

A fan palm 4 - 6 m tall, with slender trunk (NatureServe, 2015). It has a ringed, wavy trunk about 15 cm (5.9 in) in diameter. The rather ruffled, fan-shaped leaves are approximately 80 cm (31 in) in diameter and somewhat waxy to pale green with a few tiny scales on the lower surface. The flowering stalks, which can be up to 30 cm (12 in) in length, are branched, and the flowers are arranged spirally along the hairless stalks (USFWS, 2003).

Taxonomy

A member of the palm family (Arecaceae). *Pritchardia remota* is the only species of *Pritchardia* on Nihoa and can be distinguished from other species in the genus by its wavy leaves; short, hairless inflorescences; and small, round fruits (Read and Hodel 1999; 61 FR 43178) (USFWS, 2003). Kartesz considers *Pritchardia remota* in a BROAD SENSE to include the subsp. *aylmer-robinsonii*, *glabrata*, and *napaliensis*, which the USFWS and HIHP consider distinct species. USFWS lists *Pritchardia remota* in the strict sense, excluding subspecies. Federal status is found in the record for *P. remota ssp remota* (NatureServe, 2015).

Historical Range

Endemic to Nihoa (NatureServe, 2015). It may have historically occurred on Laysan Island as well (Beccari and Rock 1921) (USFWS, 2003).

Current Range

Populations are concentrated in two valleys (West Palm Valley and East Palm Valley) located on opposite sides of the island [Nihoa], approximately 0.6 km (0.4 mi) apart. The largest population is in West Palm Valley, with three smaller subpopulations in East Palm Valley, and scattered trees on steep outer walls of both valleys at the foot of basalt cliffs (Evenhuis and Eldredge 2004) (USFWS, 2009).

Critical Habitat Designated

Yes; 5/22/2003.

Legal Description

On May 22, 2003, the U.S. Fish and Wildlife Service designated critical habitat for *Pritchardia remota*.

Critical Habitat Designation

Nihoa 2 and Laysan 2 constitute critical habitat for *Pritchardia remota*.

Laysan 2—*Pritchardia remota*. This unit is critical habitat for *Pritchardia remota* and is approximately 405 ha (1,002 ac) in size, which includes a 52 ha (129 ac) hypersaline lagoon in its center. It is all on Federal land and is part of the HINWR. The unit is currently unoccupied but provides habitat essential to the conservation of 100 reproducing individuals of this long-lived perennial species. The habitat features contained in this unit that are essential for this species

include, but are not limited to, the coastal strand community that contains one or more of the following associated native plant species: *Chenopodium oahuense* and *Solanum nelsonii*. This unit is currently unoccupied but is essential to the conservation of *Pritchardia remota* because it provides habitat for the establishment of a new colony in order to achieve recovery goals for the species. This unit is also geographically separated from the occupied designated critical habitat unit on Nihoa, which serves to avoid the destruction of both colonies by one naturally occurring catastrophic event.

Nihoa 2—*Pritchardia remota*. This unit is critical habitat for *Pritchardia remota* and is 69 ha (171 ac) on federally owned land. It includes the entire island, which is part of the HINWR. This unit, which contains at least 4 colonies that consist of at least 1,074 individuals (including seedlings) of *P. remota*, provides habitat that is essential to the conservation of 100 mature, reproducing individuals of this long-lived perennial species. The habitat features contained in this unit that are essential for this species include, but are not limited to, a coastal forest community that contains one or more of the following associated native plant species: *Chenopodium oahuense*, *Sesbania tomentosa*, *Solanum nelsonii*, and *Sida fallax*. This unit is essential to the conservation of the species because it supports the only extant wild occurrence of this species and is geographically separated from the designated critical habitat unit on Laysan Island to avoid destruction by one naturally occurring catastrophic event.

Primary Constituent Elements/Physical or Biological Features

On Nihoa, the currently known primary constituent elements of critical habitat include, but are not limited to, the habitat components provided by:

- (i) *Pritchardia remota* coastal forest community and containing one or more of the following associated native plant species: *Chenopodium oahuense*, *Sesbania tomentosa*, *Sida fallax*, or *Solanum nelsonii*; and
- (ii) Elevations between sea level and 151 m (500 ft).

On Laysan Island, the currently known primary constituent elements of critical habitat include, but are not limited to, the habitat components provided by:

- (i) Coastal strand habitat with *Chenopodium oahuense* and *Solanum nelsonii*; and
- (ii) Elevations between sea level to 12 m (0 to 40 ft).

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual (inferred from USFWS, 2003)

Lifespan

Adult: > 10 years (USFWS, 2009)

Breeding Season

Adult: Spring - summer (USFWS, 2003)

Key Resources Needed for Breeding

Adult: Unknown, possible insects (USFWS, 1998)

Reproduction Narrative

Adult: It is a long-lived perennial (USFWS, 2009). Conant (1985) reported finding plants with fruit and flowers in the spring and summer. Phenology may vary somewhat from year to year, depending on rainfall and climatic factors. Pollination vectors, seed dispersal agents, specific environmental requirements, and limiting factors for this species are unknown (Service 1998d) (USFWS, 2003). The means of pollination are unknown, although a variety of insects have been observed visiting the flowers (D. Hopper, personal communication 1997) (USFWS, 1998).

Habitat Type

Adult: Terrestrial (NatureServe, 2015); riparian (USFWS, 2003)

Habitat Vegetation or Surface Water Classification

Adult: Coastal forest (USFWS, 2003)

Dependencies on Specific Environmental Elements

Adult: Dry climate (USFWS, 2003)

Geographic or Habitat Restraints or Barriers

Adult: 50 - 500 ft. elevation (USFWS, 2003)

Habitat Narrative

Adult: Found on dry gulches and cliffs (NatureServe, 2015). It occurs at elevations between 15 and 151 m (50 and 500 ft.) in relatively dry climates. Its distribution on Nihoa, however, may be related to availability of water since many individuals are found in valleys and near freshwater seeps (Service 1998d). In the *Pritchardia remota* coastal forest community, this species assumes complete dominance, creating a closed canopy and understory of thick layers of fallen fronds (Gagne and Cuddihy 1999) (USFWS, 2003).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Not available

Population Information and Trends**Population Trends:**

Not available

Species Trends:

Increasing to stable (USFWS, 2009; 2003)

Number of Populations:

4 (USFWS, 2003)

Population Size:

~1,500 wild (USFWS, 2021)

Population Narrative:

At the time of its listing as federally endangered, it was known from two extant populations (populations are referred as colonies in the recovery plan and critical habitat designation) totaling 680 plants: 387 individuals in West Palm Valley, 293 in East Palm Valley (USFWS 1996a). There are currently approximately 1,100 wild individuals and 61 outplanted individuals (USFWS, 2009). Populations on Nihoa have remained stable for several years. Currently, *Pritchardia remota* is known from four colonies on Nihoa that are found along 0.2 km (0.1 mi) of the length of two valleys on opposite sides of the island, approximately 0.6 km (0.4 mi) apart (USFWS, 2003). New Status Information: In addition to those populations cited in the previous 5-year review, new observations include the following: • In Hodel's review (2007), there are no significant morphological differences between *Pritchardia remota* and *P. aylmer-robinsonii* (found on Niihau). Hodel synonymizes *P. aylmer-robinsonii* with *P. remota* (2007, 2012). We will address this change in the next 5-year review for *P. aylmer-robinsonii*. • At the time of the last 5-year review in 2009 there were two populations totaling 1,100 individuals on Nihoa. Currently, on Nihoa, the palms still occur in large colonies in two separate valleys (West Palm Valley and East Palm Valley). A population estimate will be conducted on Nihoa in September 2017. A visit to Nihoa in 2016 observed that both populations are healthy with mature fruits and flowers present (Plentovich et al. 2016). However, the population area is constricting, where individuals do not occur at the higher elevations of the previous range (Plentovich 2017, pers comm.). Only two older palms remain on Niihau (Hodel 2012) (USFWS, 2017). The most recent census in 2017 estimated 1,500 individuals of *Pritchardia remota* on Nihoa, and at least hundreds were observed in 2021 (but no census was conducted). Nonnative plants are controlled on Nihoa. Ungulates and rodents are not present on Nihoa. A few plants are in living collections with seed collections ongoing. (USFWS, 2021)

Threats and Stressors

Stressor: Disease and predation (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: A recent major threat to the welfare of *Pritchardia remota* and its habitat include the vagrant grasshopper, an introduced insect normally occurring at more temperate latitudes in the northern hemisphere (Evenhuis and Eldredge 2004). The grasshopper was first reported on Nihoa in 1990, after having first been recorded in the main Hawaiian Islands in 1964. Populations on Nihoa were of minimal concern until 2002, and again in 2004, when a virtual plague of grasshoppers ravaged the vegetation on the island, denuding it (Gilmartin 2005). The vagrant grasshopper's population explosions are apparently triggered by warm, dry conditions. Although the vegetation appears to recover following each episode, a continuation of this pattern does not bode well for the long-term survival of *P. remota*. The introduction of rodents, especially rats (e.g., roof rat (*Rattus rattus*), Norway rat (*R. norvegicus*), Polynesian rat (*R. exulans*)), could be catastrophic for *Pritchardia remota* (USFWS 1998). Rats have been implicated in reducing reproductive capacity by eating other *Pritchardia* spp. seeds and seedlings, and damaging palm hearts (Chapin et al. 2004; Pérez et al. 2008b). Rats and mice (*Mus musculus*) are presently not

found on Nihoa, and great care must be taken not to allow stowaway rodents from shipboards to gain access to the island. Another recent threat described for this species is an unknown fungus infecting seeds (Rehkemper et al. 2008) (USFWS, 2009).

Stressor: Collection (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Chapin et al. (2004) suggest this species is vulnerable to international trade of seeds as are other rare *Pritchardia*. Palm seed dealers have offered \$20 to \$30 per ten seeds of *P. remota* (USFWS, 2009).

Stressor: Stochastic events (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Species like *Pritchardia remota* 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 by random demographic fluctuations and localized catastrophes such as hurricanes, rockslides, flooding and disease outbreaks. In the limited available habitat of the species supporting limited numbers of individuals, such events would cause severe habitat destruction and death of individual plants or entire populations. Fire and landslides are also continuing potential threats (USFWS, 2009).

Stressor: Climate change loss or degradation of habitat

Exposure:

Response:

Consequence:

Narrative: Climate change may pose a threat to this species. Fortini et al. (2013) conducted a landscape-based assessment of climate change vulnerability for native plants of Hawaii using high resolution climate change projections. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change. The assessment by Fortini et al. (2013) concluded that *Pritchardia aylmer-robinsonii* is vulnerable to the impacts of climate change, with a vulnerability score of 0.584 (on a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change). Therefore, additional management actions are needed to conserve this taxon (on Niihau) into the future. No analysis was provided for *P. remota* (USFWS, 2017).

Recovery

Reclassification Criteria:

1. Interim objectives must have been attained (USFWS, 1998).
2. A total of at least five colonies should exist on Nihoa and successful propagation and outplanting ex situ must be underway. Each of these must be stable, secure, and naturally reproducing (USFWS, 1998).

3. A preliminary target level is a minimum of 100 mature individuals per colony for *Pritchardia remota* (USFWS, 1998).

4. Each colony should be stable or increasing for a minimum of 5 consecutive years before downlisting is considered (USFWS, 1998).

Delisting Criteria:

1. Downlisting objectives must have been obtained (USFWS, 1998).

2. Delisting may require the establishment of one to three additional colonies on an island other than Nihoa. In the case of *Pritchardia remota*, Laysan Island should be considered, since a palm that may have been this species formerly occurred there (USFWS, 1998).

3. Should establishment of one to three colonies on an island other than Nihoa occur, delisting may be considered when they have reached a minimum of 100 mature individuals per colony (USFWS, 1998).

4. Each colony should be stable or increasing for a minimum of 5 consecutive years (USFWS, 1998).

5. If the establishment of any or all of these taxa on a second island proves unfeasible, delisting may be considered if the downlisting objectives have been met and the colonies persist at target levels for a minimum of 10 years (USFWS, 1998).

6. In order to initiate delisting in any of the above situations, there should no longer be a need for continued species-specific management actions, but delisting may proceed if there is a continuing need for ecosystem-wide management actions (USFWS, 1998).

Recovery Actions:

- Protect habitat and control threats (USFWS, 1998).
- Conduct research essential to conservation of the species (USFWS, 1998).
- Increase numbers and locations of *Amaranthus brownii* (USFWS, 1998).
- Establish *Pritchardia remota* on Laysan Island (USFWS, 1998).
- Evaluate potential for establishing taxa outside their historical ranges (USFWS, 1998).
- Validate and revise recovery objectives (USFWS, 1998).
- Immediate recovery actions should include collection of additional seeds for additional research into long-term seed storage techniques and establishment of additional ex situ populations (USFWS, 1998).
- An assessment of the feasibility of introducing this palm to Laysan Island should be undertaken and, if deemed advisable, the Service should proceed with attempts to establish one or more populations on that island (USFWS, 1998).
- Continue seed collection for ex situ genetic storage and reintroduction (USFWS, 2009).
- Continue to restrict human access (USFWS, 2009).
- Prevent invasion of any introduced species on Nihoa (USFWS, 2009).
- Determine and implement control methods for vagrant grasshopper (USFWS, 2009).
- Determine identity of unknown fungus, the degree of impact to seeds, and if control methods are needed (USFWS, 2009).

- Assess genetic variability within extant population and between species to determine taxonomic status of *Pritchardia remota* and *P. alymer-robinsonii* (USFWS, 2009).
- Assess feasibility of outplanting *Pritchardia remota* on Laysan, Necker, and Lehua, which are the nearest islands, and are managed by the HINWR and State of Hawaii (USFWS, 2009).
- Work with HINWR and State of Hawaii to provide ecosystem-level management of reintroduction sites (USFWS, 2009).
- Study *Pritchardia remota* populations with regard to population size and structure, geographical distribution, flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, limiting factors, and threats (USFWS, 2009).
- Update the listed entity on 50 CFR 17 to include the two individuals from Niihau as *Pritchardia remota* and delist *P. alymer-robinsonii* if genetic studies verify this taxonomic change (USFWS, 2009).
- New Management Actions:
 - NTBG has dozens of plants planted on their grounds representing many collections from Nihoa and Niihau (NTBG 2017). Waimea Arboretum has eight seeds in propagation (2016). Pahole Rare Plant Facility on Oahu has two potted plants (PEPP 2016). The Seed Conservation Lab has two collections in storage for research (Lyon Arboretum 2017).
 - In 2015, the Service funded a research project regarding optimization of seed banking methods for Hawaiian plants and the study included *Pritchardia remota*. Five hundred and thirty-two seeds (including seeds of *Pritchardia remota*) collected by the Seed Conservation Laboratory staff were sent to the National Center for Genetic Resources Preservation in Fort Collins for research on cryopreservation to extend storage life of species with short-lived seeds (PEPP 2016). Seeds of species of *Pritchardia* cannot be stored conventionally, and currently can only be stored for a few months unless they are stored via cryopreservation methods (Walters 2017, pers. comm.) (USFWS, 2017).
- Recommendations for Future Actions: No new threats and no other significant new information regarding the species' biological status have been reported since the last 5-year review in 2010. Therefore, the following recommendations for future actions are reiterated for the 5-year review for 2017.
 - Surveys and inventories—Conduct inventories of the current populations on Niihau and Nihoa to determine status.
 - Invasive plant monitoring and control—
 - o Control established ecosystem-altering nonnative invasive plant species around all populations.
 - o Control invasive nonnative species that compete with the species around all populations.
 - o Continue efforts to prevent introduction of new species to Nihoa.
 - Predator and herbivore control research—
 - o Study *Pritchardia remota* populations to determine level of threat from invertebrate herbivory by the nonnative grasshopper *Schistocerca nitans* and any additional needed recovery actions.
 - o Determine identity of unknown fungus, the degree of impact to seeds, and if control methods are needed.
 - o Control rats in the vicinity of the population on Niihau.
 - Captive propagation for genetic storage and reintroduction—Continue to collect material for genetic storage.
 - Reintroduction and translocation—Assess potential sites for establishing reintroductions on Laysan or on other NWHI such as Necker and Lehua in areas with other than limestone substrate.
 - Population biology research—
 - o Assess genetic variability within extant populations and between *Pritchardia remota* and *P. alymer-robinsonii*.
 - o Study *P. remota* populations with regard to population size and structure, geographical distribution, flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, limiting factors, and threats.
 - Human disturbance—Collecting impacts—Continue to restrict human access to Nihoa.
 - Habitat and natural process management and restoration—Work with the State of Hawaii to implement remote

monitoring methods and ecosystem-level management of wild and reintroduction sites. • Update the listed entity on 50 CFR 17.12 to include the individuals on Niihau as *Pritchardia remota* and delist and remove *P. aylmer-robinsonii* if genetic studies verify this taxonomic change (USFWS, 2017).

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: No significant new information regarding the species' biological status has been reported since the last 5-year review in 2017. Thus, the following recommendations for future actions are reiterated for the 5-year review for 2021. • Surveys and inventories—Periodically survey the population on Nihoa to assess status. • Invasive nonnative plant monitoring and control— o Continue to control invasive introduced plants on Nihoa. o Continue efforts to prevent introduction of nonnative invasive plant species to Nihoa. • Collection impacts—Continue to restrict access to Nihoa. • Predator and herbivore monitoring and control— o Continue to implement strict measures to prevent introduction of rats and mice to Nihoa. o Determine effects of predation by the nonnative grasshopper *Schistocerca nitans* and if additional recovery actions are needed. o Determine the identity of the unknown fungus observed on fruit, the impact to seeds and germination, and if control methods should be implemented. • Captive propagation for genetic storage and reintroduction—Continue collection of genetic resources for storage, propagation, and reintroduction. • Reintroduction and translocation— o Assess potential sites for establishing introductions on Laysan or other NWHI such as Mokumanamana or Lehua in areas with suitable habitat. o Increase numbers of populations and individuals within suitable habitat to reduce impacts from hurricanes and climate change. • Climate change adaptation strategy—Research suitability of habitat for reintroduction of this species in the future due to impacts of climate change, including hurricanes. • Taxonomic and genetic research—Assess genetic variability within extant colonies and determine if there are any distinct genetic differences between *P. remota* and plants previously identified as *P. aylmer-robinsonii*. • Alliance and partnership development—Continue to work with partners and other land managers in planning and implementation of remote monitoring methods and ecosystem-level restoration and management to benefit this taxon. • Update the listed entity at 50 CFR 17.12 to include individuals on Ni'ihau as *Pritchardia remota* and delist and remove *P. aylmer-robinsonii*. (USFWS, 2021)
- New Management Actions: • Site management— o Nonnative plants are controlled on Nihoa (Plentovich et al. 2018, pp. 13–17; Rounds et al. 2020, pp. 6-7, 14-15; Rounds et al. 2021, pp. 28-30). o A new weather station was installed near the palm population as part of the remote monitoring system (Plentovich et al. 2018, p. 23). • Collection and propagation for genetic storage and reintroduction— o The Lyon Seed Conservation Laboratory reported more than 400 seeds collected from a living collection of *P. remota* at Koko Crater (O'ahu) that were used for storage testing or genetic research (Lyon Arboretum 2020). o The Kaua'i Mid-Elevation Nursery (KMEN) reported two individuals in the living collection (KMEN 2020). o Waimea Arboretum reported storage of eight seeds representing one founder from Nihoa (Waimea Arboretum 2017, 2018). (USFWS, 2021)

References

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

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed August 2016

USFWS. 2009. *Pritchardia remota* (Lo'ulu)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii

USFWS 2003. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Five Plant Species From the Northwestern Hawaiian Islands, Hawaii. 68 Federal Register 99. May 22, 2003. Pages 28054 - 28075.

USFWS 2009. *Pritchardia remota* (Lo`ulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii

Designation of Critical Habitat for Five Plant Species From the Northwestern Hawaiian Islands, Hawaii. 68 Federal Register 99. May 22, 2003. Pages 28054 - 28075. USFWS. 2021. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Pritchardia remota* (loulou). 9 pp.

USFWS. 2009. *Pritchardia remota* (Lo`ulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2017. 5-YEAR REVIEW. Short Form Summary. Species Reviewed: *Pritchardia remota* (Loulou).

U.S. Fish and Wildlife Service. 1998. Final Recovery Plan for Three Plant Species on Nihoa Island. U.S. Fish and Wildlife Service, Portland, Oregon. 83 pp.

USFWS 2009. *Pritchardia remota* (Lo`ulu) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service Pacific Islands Fish and Wildlife Office Honolulu, Hawaii.

USFWS. 2021. 5-YEAR REVIEW Short Form Summary Species Reviewed: *Pritchardia remota* (loulou). 9 pp.

SPECIES ACCOUNT: *Rhynchospora knieskernii* (Knieskern's Beaked-rush)

Species Taxonomic and Listing Information

Listing Status: Threatened; 07/18/1991; Northeast Region (Region 5) (USFWS, 2015)

Physical Description

This grass-like plant has been considered an annual; however, recent information suggests that the plant may be a perennial or semi-perennial (W. Brumback, New England Wild Flower Society, pers. comm. 1993). *R. knieskernii* grows from 1.5 to 60 cm high (0.6 to 24 in), has slender culms (stems) branching from the base, and short, narrowly linear leaves. Small spikelets (flower clusters) are numerous and occur at distant intervals along the entire length of the culm. The achene (fruit) is obovate, narrow at the base, 1.1 to 1.3 mm long (0.04 to 0.05 in), and equal in length to the six downwardly-barbed, or rarely, upwardly-barbed attached bristles. A tubercle (beak), which is the persistent base of the two-cleft style on top of the achene, is about one-half the length of the achene. (USFWS, 1993)

Taxonomy

Distinct member in genus of around 200 species. (NatureServe, 2015)

Historical Range

Rhynchospora knieskernii has always been considered rare (Knieskern 1857, Robinson and Fernald 1908, Stone 1911). Historically, the species was known to occur in Atlantic, Burlington, Camden, Monmouth, and Ocean Counties in New Jersey. (USFWS, 1993)

Current Range

This species is now endemic to 5 counties within the New Jersey Pine Barrens, where fewer than 40 recent occurrences have been documented. (NatureServe, 2015)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Key Resources Needed for Breeding

Adult: Knieskern's beaked-rush seeds were found to require cold/wet stratification and light to germinate. (USFWS, 2008)

Reproduction Narrative

Adult: Knieskern's beaked-rush seeds were found to require cold/wet stratification and light to germinate. (USFWS, 2008). Culms develop in May with most plants supporting a single culm (stem) with three to four spikelets (clusters of seeds); however, it is not unusual for some plants to have multiple culms in addition to the main stem. Typically, spikelets begin to form on culms in June and flower early August. Achenes (seeds) begin to form in late August and are dispersed

from mid-September until late December. During the dispersal period, leaves senesce and winter buds develop, which remain photosynthetic until March. (USFWS, 2019).

Habitat Type

Adult: Palustrine (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Bog/fen, forested wetland (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Soil moisture (USFWS, 2008)

Geographic or Habitat Restraints or Barriers

Adult: Restricted to early successional habitats in pitch pine lowland forests within pine barrens

Spatial Arrangements of the Population

Adult: Dense, local patches (NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2019)

Habitat Narrative

Adult: Restricted to early successional habitats in pitch pine lowland forests within pine barrens. Substrates are highly acidic, nutrient poor, fine grained mineral soils, frequently over clay deposits, but sometimes found on bog iron deposits. Soil composition primarily consisted of sand (87 to 92%), with a small proportion of clay (7 to 13%), and silt (5 to 10%). Soil is acidic, nutrient poor, and generally retains more water in the top organic horizon than lower alluvial horizon. Sites typically have fluctuating water regimes. Species tends to occur in dense, local patches. The species is a poor competitor and is usually found on bare or sparsely vegetated sites that are maintained open through natural disturbances such as fire or flood scouring, or through human-caused disturbances such as roadside, railroad, or powerline right-of-way maintenance, or in inactive sand or clay pits. Soil moisture appears to be a limiting factor determining the establishment of Knieskern's beaked-rush. (USFWS, 2008; NatureServe, 2015). Experimental data determined that soil moisture between 10 and 12.5 percent was optimal for growth (Sobel 2015), and populations where the soil moisture remained either above or below 10 to 12.5 percent had lower densities (Bien and Sobel 2015). (USFWS, 2019).

Dispersal/Migration**Dispersal/Migration Narrative**

Adult: Seed dispersal mechanisms are not documented; however, bristles on the achenes could assist in animal dispersal. (USFWS, 1993)

Population Information and Trends**Population Trends:**

Declining (USFWS, 2008)

Number of Populations:

73 occurrences (USFWS, 2008)

Population Size:

96 (USFWS, 2019).

Additional Population-level Information:

Current results suggest KBR populations show high spatial variability at the plot scale and year-to-year spatial variability (Palmer and Baumgarten pers. comm. 2012). (USFWS, 2019).

Population Narrative:

The number of known occurrences of Knieskern's beaked-rush increased from 50 in 1993 to 73 in 2007, due to additional survey efforts and likely increased reporting of the species. During field studies conducted from 1994 to 1996, over 60 percent of extant occurrences visited were found to be declining. (USFWS, 2008)

Threats and Stressors

Stressor: Habitat loss and degradation due to development (USFWS, 2008)

Exposure:

Response:

Consequence:

Narrative: Wetlands within the range of Knieskern's beaked-rush continue to be lost, but at a slowing rate. From 1972 to 2001, New Jersey lost about 190,000 acres of wetlands, a decline of about 20 percent. (USFWS, 2008)

Stressor: Habitat succession (USFWS, 2008)

Exposure:

Response:

Consequence:

Narrative: Habitat succession and resulting competition with woody and herbaceous species continues to be a major cause of loss of Knieskern's beaked-rush habitat, particularly at disturbed sites (Radis, 1995; Gordon, 1996). Erosion, soil compression, and rut creation caused by off-road vehicles also continues to be a significant threat causing degradation of habitat (Radis, 1995). (USFWS, 2008)

Stressor: Road maintenance (USFWS, 2008)

Exposure:

Response:

Consequence:

Narrative: Road maintenance, particularly bulldozing and mowing, were identified as major threats to roadside occurrences (Gordon, 1996; Dodds and Cartica, 1998). (USFWS, 2008)

Stressor: Trash dumping (USFWS, 2008)

Exposure:

Response:

Consequence:

Narrative: Dumping of trash directly onto plants, at roadside sites or within clay pits was also identified as a concern. In some cases trash dumping was to a degree that the plants and or habitat were buried (Radis, 1995; Dodds and Cartica, 1998).

Stressor: Alterations in hydrology (USFWS, 1993)

Exposure:

Response:

Consequence:

Narrative: *R. knieskernii* appears to require relatively constant damp- to-wet soil conditions throughout most of the growing season. Human activities that alter site hydrology, or natural events such as drought, could eliminate site suitability for *R. knieskernii*. In addition, subtle changes that result in drier site conditions could promote vegetative succession, thereby eliminating *R. knieskernii*. (USFWS, 1993)

Stressor: Fire (USFWS, 1993)

Exposure:

Response:

Consequence:

Narrative: Fire can create suitable conditions for the species; however, Gordon (1993) noted that a previously unreported occurrence of the species within a burned pitch pine lowland was no longer extant due to invasion by other plant species following a subsequent fire. Fire can, therefore, be beneficial or detrimental to the establishment and maintenance of *R. knieskernii* depending on the timing, duration, and intensity of the burn. (USFWS, 1993)

Recovery

Reclassification Criteria:

Reclassification criteria are not available.

Recovery Priority Number: 14

Delisting Criteria:

1. Permanent habitat protection is secured for a minimum of nine occurrences. This number represents the sum of known populations that are (1) either self-sustaining or will require minimal management for long-range maintenance, and (2) already occur on public lands or meet any of the biological criteria, stated below, that would warrant land acquisition for the primary objective of protecting the population. Habitat will be considered permanently protected when the *R. knieskernii*'s site, including an adequate buffer that ensures maintenance of the hydrological regime, is secured either through acquisition or conservation easement, and a formal commitment to long-range management is made by a government agency or conservation organization. (USFWS, 1993). Not met as of 2019 (USFWS, 2019).
2. The species is proven to be an efficient colonizer, as indicated by monitoring results, life history information, and/or the results of experimental introductions. (USFWS, 1993). Ongoing in 2019 (USFWS, 2019).
3. A post-delisting strategy for monitoring the species' population dynamics, as well as introducing (if and when necessary) the plant to suitable habitats, is in place. (USFWS, 1993).

Not met as of 2019 (USFWS, 2019).

4. No evidence of decline in the species' status is seen by 1996. This time frame takes into account the apparent stability or improvement in the status of the species seen since its listing two years ago. (USFWS, 1993). Not achieved as of 2019 (USFWS, 2019).

Recovery Actions:

- Provide protection to populations and their habitat at a level needed to achieve recovery objectives. (USFWS, 1993)
- Monitor the species' rangewide status. (USFWS, 1993)
- Determine the capacity of the plant to colonize new sites and establish populations. (USFWS, 1993)
- Develop a post-delisting strategy for maintaining the species in suitable habitats. (USFWS, 1993)
- New in 2019 - 1: Secure Protection of Occurrences - Re-evaluate the status and protection needs of the occurrences currently known from public or otherwise-protected lands (including but not limited to the 13 sites listed in Table 1). Priority 2; Task Numbers 1.1 and 1.3. - Pursue formal, long-term KBR protection and management agreements with landowners to include, as appropriate. Priority 2; Task Numbers 1.1 and 1.3 o Establish buffer zone; o Conduct prescribed burns to open canopy and cycle nutrients into soil; o Trim manually of woody species encroaching KBR populations; and o Create some human-induced disturbance to maintain early successional status. - The microsite requirements are generally within pitch pine lowland habitats adjacent to wetlands, so protection agreements could be associated with wetland buffers and other wetlands protection mechanisms. - Conduct a study to determine any correlations between protective buffer width and changes in population size and vigor. Priority 2; Task Number 3.3 - Determine impact of groundwater withdrawals or changes in surface runoff on KBR populations. Priority 2; Task Number 3.3 - Characterize the type and degree of habitat disturbance (i.e., fire) that is beneficial to the species. Priority 2, Task Number 3.3 - Conduct applied habitat management to determine the effects of fire on the species. Priority 2, Task Number 3.3 - Establish protective buffers and / or restrictions on groundwater withdrawal to ensure maintenance of hydrological regime for KBR wetlands. Priority 3; Task Number 1.6 - Develop Best Management Practices to protect KBR habitat, and encourage their adoption by Federal and State regulatory agencies, local governments, and public and private landowners. Priority 3; Task Number 1.6 - Incorporate protection of KBR into local planning efforts, especially where multiple occurrences are clustered in small watersheds. Priority 3; Task Number 1.6 - Continue to protect KBR sites through various regulatory processes as necessary and appropriate. Priority 3; Task Number 1.6 (USFWS, 2019).
- New in 2019 - 2: Continue to Characterize Species' Biology and Life History - Conduct research on the ability of seeds to remain viable in the seedbank over long time periods. Priority 3; Task Number 3.2 - Investigate KBR root anatomy and hormonal response to varying soil conditions to determine adaptive mechanisms. Priority 3; Task Number 3.2 - Conduct research to determine if edaphic factors or association with other plant species in the community influence the degree of mycorrhizal colonization. Priority 3; Task Number 3.2 - Investigate the impact of climate change on the species and its habitat. Priority 2; Task Number 3.3 (USFWS, 2019).

- New in 2019 - 3: Monitor Population and Track Recovery - Develop a protocol for monitoring and assessing trends to determine if KBR is a naturally ephemeral species. Such information would be relevant to whether the species' status is more appropriately measured by the balance of increasing and declining sites than by whether known sites are stable or improving. Priority 2; Task Number 2.3 - Survey KBR sites to obtain updated information on the species' status and trends, applying the aforementioned protocol, and ensure information is entered into Natural Heritage Program databases. Priority 2; Task Number 2.3. - Develop a method to distinguish new discoveries from recently established populations. Priority 2; Task Number 2.3 (USFWS, 2019).
- Identify sites suitable for long-term protection agreements, ensuring sites are representative of Knieskern's beaked-rush historical range limits and / or genetic variability. (USFWS, 2008)
- Pursue formal, long-term Knieskern's beaked-rush protection agreements with landowners. (USFWS, 2008)
- Conduct a study to determine any correlations between protective buffer width and changes in population size and vigor. (USFWS, 2008)
- Determine impact of groundwater withdrawals or changes in surface runoff on Knieskern's beaked rush populations. (USFWS, 2008)
- Establish recommended protective buffers and / or restrictions on groundwater withdrawal to ensure maintenance of hydrological regime for Knieskern's beaked-rush wetlands. (USFWS, 2008)
- Develop Best Management Practices to protect Knieskern's beaked-rush habitat, and encourage their adoption by Federal and State regulatory agencies, local governments, and public and private landowners. (USFWS, 2008)
- Incorporate protection of Knieskern's beaked-rush into local planning efforts, especially where multiple occurrences are clustered in small watersheds. (USFWS, 2008)
- Continue to protect Knieskern's beaked-rush sites through various regulatory processes as necessary and appropriate. (USFWS, 2008)
- Conduct applied habitat management to determine the effects of fire on the species. (USFWS, 2008)
- Study seed dispersal mechanisms. (USFWS, 2008)
- Conduct research on the ability for seeds to remain viable in the seed bank over long time periods. (USFWS, 2008)
- Measure fluctuations in hydrology throughout an entire growing season and across years with different climatic conditions to better characterize optimal habitat conditions for the species. (USFWS, 2008)
- Characterize the type and degree of habitat disturbance that is beneficial vs. deleterious to the species. (USFWS, 2008)
- Investigate Knieskern's beaked-rush root anatomy and hormonal response to varying soil conditions to determine adaptive mechanisms. (USFWS, 2008)
- Investigate the impact of climate change on the species and its habitat. (USFWS, 2008)
- Develop a scheme for monitoring and assessing trends to determine if Knieskern's beaked-rush is a naturally ephemeral species. Such information would be relevant to whether the species' status is more appropriately measured by the balance of increasing and declining sites than by whether known sites are stable or improving. (USFWS, 2008)
- Survey Knieskern's beaked-rush sites to obtain updated information on the species' status and trends, applying the aforementioned scheme, and ensure information is entered into

- the Natural Heritage Program databases. (USFWS, 2008)
- Develop a method to distinguish new discoveries from recently established populations. (USFWS, 2008)

References

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed July 2016

NatureServe Explorer: an encyclopedia of life [web application]. Accessed 07/5/2016

USFWS. 1993. Knieskern's Beaked-Rush (*Rhynchospora knieskernii*,) Recovery Plan. Hadley, Massachusetts

USFWS. 2008. Knieskern's beaked rush 5-Year Review. New Jersey Field Office, Pleasantville, New Jersey

USFWS. 2019. Knieskern's Beaked-rush (*Rhynchospora knieskernii*) 5-Year Review: Summary and Evaluation. USFWS, Galloway, New Jersey. July 2019. 23 pp.

USFWS. 2019. Knieskern's Beaked-rush (*Rhynchospora knieskernii*) 5-Year Review: Summary and Evaluation. USFWS, Galloway, New Jersey. July 2019. 23 pp.

SPECIES ACCOUNT: *Sagittaria fasciculata* (Bunched arrowhead)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4) (USFWS, 2015) 8/31/1979

Physical Description

An aquatic perennial herb with erect, emergent leaves, 1.5-3.5 dm long. In May and June, 1-several flowering stems appear bearing white flowers arranged in whorls; female flowers on the lowest whorls, males on the upper ones (NatureServe, 2015).

Taxonomy

The concept of *Sagittaria fasciculata* in Kartesz (1994) is narrower than that in Kartesz (1999). Kartesz (1994) recognized *S. graminea* var. *macrocarpa*. However, Kartesz (1999) includes *S. graminea* var. *macrocarpa* as *S. fasciculata*; Weakley (2012) and Flora North America vol. 22 also recognize that material called var. *macrocarpa* was mostly misapplied and is appropriately attributed to *S. fasciculata* (NatureServe, 2015).

Historical Range

Historical in Henderson and Buncombe Cos., North Carolina. (NatureServe, 2015)

Current Range

Endemic to North Carolina and South Carolina. Extant in Henderson Co., North Carolina and Greenville Co., South Carolina. (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Asexual (NatureServe, 2015)

Lifespan

Adult: <2 years? (USFWS, 2014)

Reproduction Narrative

Adult: According to Cooper et al., 1977 (B77COO01HQUS), this species may be limited to vegetative means of reproduction as no seedlings have been found. However, Newberry, 1987 (U87NEW01HQUS) reported seed set in the populations she studied, though the presence of seedlings was not noted.; *Sagittaria fasciculata* typically is found in very gently sloping areas with slow, continuous seepage of cool, clear water. The continuous seepage appears to be the most important factor in the ecology of the species. Canopy closure may differ greatly in different populations but the slow continuous seepage is one factor that is always present. ASEXUAL (NatureServe, 2015). There is only a single effort to obtain demographic level information for *S. fasciculata* (Newberry, 1991a). Newberry followed the survival of 100 marked plants during

1985- 1987. It is unclear at what frequency these plants were monitored; however, Newberry states that only 10% of the marked plants could be relocated two years after first being marked (in March, 1985). From this, she concludes that *S. fasciculata* plants may not live longer than two years – however this hypothesis requires further investigation before it can be generally accepted (USFWS, 2014).

Habitat Type

Adult: Seeps (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: Species inhabits very gently sloping areas with some standing water refreshed by slow continuous seepage of cool clear water. Appropriate habitat for this species is typically found in a narrow band at the bluff-floodplain ecotone. The seeps originate at the base of the bluffs and *Sagittaria fasciculata* is generally found near, but not at, the origin of the seep (water flow at the seep origin is usually too swift or too heavy to allow for colonization). Appropriate habitats often continue along the edge of the bluff downslope from the seep, but generally do not extend far into the floodplain proper because there the seepage tends to spread out and the water stagnates (NatureServe, 2015). High ecological integrity of the community and site fidelity as well as low tolerance range are inferred based on the low number of known populations and the specific habitat requirements of the species.

Dispersal/Migration***Population Information and Trends*****Population Trends:**

Decreasing to Stable (NatureServe, 2015)

Number of Populations:

36 (USFWS, 2020)

Population Size:

10,000 - 1,000,000 individuals (NatureServe, 2015)

Population Narrative:

Can withstand timbering, but not grazing or drainage of habitat. Locally abundant in upper Piedmont, in Greenville County, SC. The entire species population size is estimated to be between 97,500-120,000 rosettes (USFWS 2014). The USFWS Recovery Plan and 5 Year Review (2014) recognize 11 populations, where a population is defined as colonies of plants connected

by drainage and in close proximity to one another < 2 km). 37 colonies are recognized in these 11 populations as of 2014. Element Occurrences (EOs) fall within these 11 populations; and between North Carolina and South Carolina Natural Heritage Programs there are 44 EOs including extirpated occurrences (NatureServe, 2015). NatureServe (2015) also estimates that there are between 10,000 – 1,000,000 total individual rosettes and between 6 and 80 populations. Moderate resiliency is inferred based on the species ability to withstand timbering and the use of herbicides on right-of-ways and other maintained areas that may harm individual plants but may also help in limiting succession (USFWS, 2014). Moderate representation and redundancy are inferred based on the number of individuals and populations. Short-term Trend: Decline of <50% to Relatively Stable Short-term Trend Comments: The 5 year review of this species by the USFWS (2014) summarizes what information is available on population trends. Most populations in North Carolina were visited at least once in the late 1990's through the mid 2000's, many of the colonies within the populations weren't revisited more than once if any. For those that were revisited, declines were noted due to stagnation of the water, sedimentation, drying substrate or insufficient waterflow. Populations in South Carolina haven't been revisited since initial work in 2000 (USFWS 2014) (NatureServe, 2015).

Threats and Stressors

Stressor: Conversion to pasture/livestock trampling (USFWS, 2014)

Exposure:

Response:

Consequence: loss of habitat/loss of individuals

Narrative: Conversion to pasture and/or cattle trampling is listed as a threat to this species (USFWS, 2014).

Stressor: Powerline clearing (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat/Loss of individuals

Narrative: Powerline clearing is listed as a threat to this species (USFWS, 2014).

Stressor: Siltation (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Siltation is listed as a threat to this species (USFWS, 2014).

Stressor: Weather (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Increases and decreases in the flow of surface water were correlated with declines in the number of plants. However, most declines were associated with decreased flow and partial drying of the substrate. In a subsequent unpublished report, Newberry (1991b) described “significant changes” to habitat resulting from nutrient runoff, flooding, and sedimentation following heavy rains. Populations located adjacent to streams typically suffer scouring and sedimentation during heavy flows, while seeps tend to improve as a result of increased

hydration, reduced stagnation and increased suitable habitat area. The weather-related threats are likely to be intensified under most general circulation climate change models (Karl et al. 2009) (USFWS, 2014).

Stressor: Invasive exotics (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat/Competition

Narrative: Invasive exotics (esp. *Ligustrum* spp. and *M. keisak*, ten sites) are listed as a threat to this species (USFWS, 2014).

Stressor: Encroachment by competitive native vegetation (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat/Competition

Narrative: Encroachment by native competitive vegetation (six sites) is listed as a threat to this species (USFWS, 2014).

Stressor: Herbicide drift (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Across the range of the species, several colonies of *S. fasciculata* occur in managed road, railroad, or utility rights-of-way (ROW) where overspray or drift from herbicides poses a threat to *S. fasciculata* (Bunch, M., SCDNR, pers. comm. 2010; Geosyntec, 2009; Newberry, 2000). Overspray or drift has been implicated in at least temporary reductions in the number of *S. fasciculata* plants in a given area, however in some instances these declines may have been offset by a reduction in the density of encroaching vegetation (primarily woody), which also poses a threat to *S. fasciculata* (Bunch, M., SCDNR, pers. comm. 2010; Worton, A., Geosyntec, pers. comm. 2010; Geosyntec, 2009). Despite attempts by SCDNR to inform utility companies about consistent, appropriate management practices to benefit *S. fasciculata*, managed right-of-ways continue to be an impediment to conservation efforts for this species (Bunch, M., SCDNR, pers. comm. 2010) (USFWS, 2014).

Stressor: Poaching (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of populations/Loss of individuals

Narrative: This was not known to be a significant threat to *S. fasciculata* at the time of listing, but in March 2012, this plant was poached from the Bunched Arrowhead Heritage Preserve in South Carolina. SCDNR staff discovered a 2' x 2' section of *S. fasciculata* plants missing. Whoever stole the plants came prepared with tools to cut, dig and remove the plants en masse. SCDNR offered a reward to anyone who provided information regarding this theft, but they never received any information (SCDNR 2012). Although this new evidence of poaching is concerning and the Service will closely monitor this potential threat with partners, we do not have evidence to suggest it is a significant threat at this time (USFWS, 2014).

Stressor: Development (USFWS, 2014)

Exposure:**Response:****Consequence:** Loss of habitat

Narrative: The North Carolina Plant Conservation and Protection Act (NC State Code Article 19B, § 106-202.12) provides limited protection from unauthorized collection and trade of plants listed under that statute. However, this statute does not protect the species or its habitat from destruction in conjunction with development projects or otherwise legal activities. Plant species are afforded less protection in South Carolina, where they are protected only from disturbance at South Carolina Heritage Preserves (SC State Code of Regulations Part 123 § 200-204). There are no other statutes that afford significant protections to *S. fasciculata*. In South Carolina, one colony is afforded some protection through a registration agreement between the landowner (Furman University) and SCDNR Heritage Trust Program. This agreement, signed in 1981, recognizes the natural heritage significance of the property, and acknowledges the mutual interests of SCDNR and the landowner in preserving its habitat. The agreement is non-binding but remains in effect. Despite the University authorizing activities that threaten the long-term viability of this *S. fasciculata* population (Newberry, 2000), faculty of Furman University Biology Department have been instrumental in increasing awareness among the University administration staff about the significance of the site and activities that adversely affect it (Dr. Joe Pollard, Furman University, pers. comm. 2010) (USFWS, 2014).

Recovery**Delisting Criteria:**

Protect existing populations and essential habitat. Survey to determine population/colony priority and land ownership patterns. Obtain the most appropriate and highest protection for each population or colony. Manage the populations to ensure survival of the plants (USFWS, 1983).

Conduct population and ecological studies. Conduct studies on the abiotic factors of the species habitat. Conduct studies on the biotic factors of the species habitat. Conduct demographic studies. Search for additional populations. Utilizing the data obtained in this section, determine the species essential habitat. Support further studies of the species (USFWS, 1983).

Conduct transplant and propagation studies. Transplant studies. Propagation studies (USFWS, 1983).

Monitor colonies, populations, permanent plots, transplanted colonies, and propagation facilities at regular intervals. Develop censusing techniques and monitoring schedule. Monitor at least twice yearly. Appoint local individuals to regularly monitor the sites (USFWS, 1983).

Enforce laws and regulations protecting the species and its essential habitat (USFWS, 1983).

Inform public of species status and recovery plan objectives. Prepare and distribute brochures on recovery plan objectives. Provide information for press release. Prepare articles for popular and scientific publications (USFWS, 1983).

Recovery Actions:

- Obtain the most appropriate and highest protection for each population or colony (Recovery Task 12, Priority 1). Once updated information on the size and vigor of extant colonies is obtained, protection efforts should be undertaken immediately. The current number of protected colonies/populations is far less than that specified in the current set of recovery criteria (USFWS, 2014).
- Estimate current colony and population size and vigor (Recovery Task 111, priority 2). Updated information on the size and vigor of extant colonies/populations is critically needed in order to assess and refine protection priorities. It would be particularly useful to include detailed mapping of the spatial extent of occupied habitat (USFWS, 2014).
- Monitor colonies, populations, permanent plots, transplants and propagation facilities (Recovery Task 4, priority 3). The lack of monitoring data hinders objective assessments of colony/population trends. Anecdotal observation suggests that this species exhibits considerable fluctuation in response to drought and heavy rainfall events; monitoring would help to determine the range of acceptable fluctuations in colony/population size, and critical thresholds for management intervention.

Conservation Measures and Best Management Practices:

- Recommendations for Future Actions: The 2014 5-year review included a list of recommendations to improve recovery of the species. These actions, listed below, remain applicable to species recovery. Once updated information on the size and vigor of extant colonies is obtained, protection efforts should be undertaken immediately. The current number of protected colonies/populations is far less than that specified in the current set of recovery criteria. Updated information on the size and vigor of extant colonies/populations is critically needed in order to assess and refine protection priorities. It would be particularly useful to include detailed mapping of the spatial extent of occupied habitat. The lack of monitoring data hinders objective assessments of colony/population trends. Anecdotal observation suggests that this species exhibits considerable fluctuation in response to drought and heavy rainfall events; monitoring would help to determine the range of acceptable fluctuations in colony/population size, and critical thresholds for management intervention. In light of new information, additional future actions are recommended below: Work with partners and species experts to develop a standardized monitoring protocol that could be used on many different types of bunched arrowhead sites. Work with partners and land managers to conduct range-wide monitoring. Provide support and, if feasible, pool resources for management and monitoring. Prioritize unprotected sites critical for recovery and work toward permanent protection. Develop a plan for conserving the species in situ collections – through either conservation gardens or seed banking. As staff time and office resources allow, consider the need to reevaluate the recovery criteria and amend the recovery plan. If deemed necessary, work with the Regional Office to include recovery plan updates and/or amendments into the regional workplan. Work with and support Furman University to complete genetic investigations.

References

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

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia.

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016.

U.S. Fish and Wildlife Service. 2014. Bunched arrowhead (*Sagittaria fasciculata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.” USFWS. 2020. Bunched arrowhead (*Sagittaria fasciculata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina. 40 pp.

U.S. Fish and Wildlife Service. 1983. Bunched Arrowhead Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 37 pp.

U.S. Fish and Wildlife Service. 2014. Bunched arrowhead (*Sagittaria fasciculata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office, Asheville, North Carolina.

USFWS. 2020. Bunched arrowhead (*Sagittaria fasciculata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Asheville Ecological Services Field Office Asheville, North Carolina. 40 pp.

SPECIES ACCOUNT: *Sagittaria secundifolia* (Kral's water-plantain)

Species Taxonomic and Listing Information

Listing Status: Threatened; Southeast Region (R4) (USFWS, 2015) 4/13/1990

Physical Description

An aquatic perennial herb with 2 types of leaves: in swift shallows, the leaves are linear, rigid, and sickle-shaped, 5-8 cm long; in quiet, deep waters, leaves can be up to 3 dm long and are more quill-shaped. Flowering stems are erect, emergent, and bear separate male and female flowers near the apex. Only the white petaled male flowers are conspicuous. Blooms infrequently from May into the fall. (NatureServe, 2015)

Historical Range

See current range/distribution.

Current Range

Known from the Little River drainage of northeast Alabama and northwest Georgia, Sipsey Fork of the Black Warrior River in northwest Alabama, and Hatchet Creek in north-central Alabama (Chafin 2007). The Town Creek population in northeast Alabama is believed to have been destroyed (USFWS 1991). (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Breeding Season

Adult: Although infrequent, flowering occurs from May into July, and intermittently into the fall (Kral 1982, 1983) (USFWS, 2014).

Reproduction Narrative

Adult: Kral's water-plantain is clonal and reproduction is primarily asexual, which suggests there may be low genetic variability within the isolated populations. Although capable of sexual reproduction, Kral's water-plantain spreads primarily by growth of its underwater stems (rhizomes). Female and male flowers occur separately on the same plant, with male flowers held on upper branches, female on lower. Plants flower only in full sun and where low water levels permit growth of above water leaves. Bees are likely pollinators but little is known about Kral's water-plantain reproduction. Whetstone (1988) observed flowering in only 1 percent of this *Sagittaria* and only in areas of direct sunlight and at a water level that allowed emergent leaves. Many of the sites supporting local populations are in less than these optimum conditions for flowering: therefore, it is important to maintain as much suitable habitat as possible to encourage reproduction by sexual means. Sexual reproduction increases genetic variability, which enables species to adapt to changing conditions (USFWS, 2014). Although infrequent, flowering occurs from May into July, and intermittently into the fall (Kral 1982, 1983) (USFWS, 2014).

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Undammed riverine reaches on exposed shoals or rooted among loose boulders in sands, gravels, and silts in pools up to 1 m deep. Stream bottoms are typically narrow and bounded by steep slopes (NatureServe, 2015).

Dispersal/Migration***Population Information and Trends*****Population Narrative:**

At the time of listing, Kral's water-plantain was known from only a single population in the Little River system in northeast Alabama (DeKalb and Cherokee counties) and northwest Georgia (Chattooga County) (55 FR 13907). A historical population from Town Creek (DeKalb County, Alabama) is likely extirpated from the area (Godwin and Schotz 2017b). On August 11, 1993, biologists noted a population of Kral's water-plantain in shoals at the confluence of Caney Creek and Sipsey Fork in the Bankhead National Forest, Winston County, Alabama (Reichert 1993). On July 26, 2001, Kral's water-plantain was found growing with Cahaba lilies in crevices along Hatchet Creek, Coosa County, Alabama (Threlkeld 2001). On April 16, 2005, two clusters of Kral's water-plantain were discovered attached to bedrock at the bottom of Brushy Creek, Winston County, Alabama (Threlkeld 2005). On October 1, 2015, a population of Kral's water-plantain was discovered in Rush Creek, a tributary to Brushy Creek, on the Bankhead National Forest, Winston County, Alabama (John Moran, pers. comm. 2019). Additional occurrences of the species were discovered in the Brushy and Sipsey forks in 2015–2017 surveys, for nine total sites in the Bankhead National Forest. (USFWS, 2020)

Threats and Stressors

Stressor: Mining (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Mining can directly impact water quality and hydrology (USFWS, 2014).

Stressor: Agriculture (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Agriculture can directly impact water quality and hydrology (USFWS, 2014).

Stressor: Development (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Development of private land near Little River Canyon can directly impact water quality and hydrology (USFWS, 2014).

Stressor: Impoundments (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Impoundments exist over large areas of presumed suitable habitat on the Little River and may have destroyed undocumented populations (Department of the Interior 1990). Four large impoundments exist along a five mile stretch of the West Fork of the Little River and two are present below the Georgia locality on the East Fork. The impoundment of Lake Weiss in Cherokee County, Alabama, in the 1960s flooded suitable habitat along Yellow Creek and several miles of the Little River. In the past, dams along two creeks, which flow into the Little River, have broken and flooded portions of suitable habitat. Cracks and leaks have been observed on the dam above DeSoto Falls and a portion of a dam near the Georgia population has deteriorated (Whetstone 1988). Several existing populations are threatened by unstable impoundments that could break and eliminate or degrade populations and suitable habitat (McCartney 1999) (USFWS, 2014).

Stressor: Inadequacy of existing regulations (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: There are no State laws, in Alabama, that are protective of Kral's water plantain and its habitat. Therefore, the only protection afforded to this species in Alabama is on Federal land or on Federal projects under Section 7 of the ESA. Bankhead National Forest management practices do not apply to the potential development of private inholdings within the Forest. ESA take provisions also do not apply to plants on private lands, where a significant portion of the Kral's water plantain population is found. State protections are in place for the species in Georgia but do not provide for the protection against habitat destruction. In Georgia, listed plants, or those proposed for listing, are protected by the Wildflower Preservation Act of 1973. This legislation prohibits taking of plants from public lands without a permit and regulates the sale and transport of plants within the State. This statute does not provide protection against habitat destruction, which is the principal threat (USFWS, 2014).

Stressor: Recreation (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Increased recreational use of streambed habitats on Federal land, particularly by off-road vehicles during low-flow periods, is a threat that warrants further study and possible management actions. Use of stream channels by recreational off-road vehicles on National Park Service and U.S. Forest Service lands is a growing problem (Mary Shew, NPS, pers. comm. March 2014). Destruction of habitat from off-road vehicle (ORV) is also likely occurring in streams on public land. Both the Forest Service and National Park Service recognize this as a potential problem and will be attempting to manage ORV usage (Ryan Shurette, USFS, pers. comm., February 2014, Mary Shew, NPS, pers. comm., March 2014) (USFWS, 2014).

Stressor: Sewage (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Siltation, impoundments, and eutrophication due to sewage are threats to this species. Activities that increase stream turbidity or siltation from erosion pose a threat to this species by reducing the amount of light reaching this submersed plant and burying it under silt. Eutrophication may lead to algal growth on the plant and result in degraded water quality (USFWS, 2014).

Recovery

Delisting Criteria:

Species will be considered for delisting when viable populations have been documented in three or more river basins within the Cumberland Plateau and within three or more tributaries of each river basin. A viable population is a reproducing population of sufficient size and genetic variability to sustain itself in perpetuity (USFWS, 2014).

Each population has been found to be viable through periodic monitoring for 15 or more years (USFWS, 2014).

Populations and supporting habitat in each river basin have sufficient long-term protection that the species no longer qualifies for protection under the Endangered Species Act (USFWS, 2014).

Recovery Actions:

- Gather base-line data on all populations and initiate long-term monitoring on sites, particularly on the secure, protected sites (USFWS, 2014).
- Develop habitat suitability indices using GIS to predict potential locations of additional populations (USFWS, 2014).
- Conduct additional field surveys to locate additional populations (USFWS, 2014).
- Since the discovery of the Hatchet Creek population, new surveys should be conducted in the Piedmont Region (USFWS, 2014).
- Work to obtain protection for sites adjacent to privately-owned lands (USFWS, 2014).
- Assess the threat of increased off-road vehicle use in stream channels where Kral's water-plantain is found (USFWS, 2014).
- Implement tasks identified in the recovery plan, except for number 6, related to reintroduction of the plant (USFWS, 2014).
- Revise recovery plan to address changes in known distribution (USFWS, 2014).
- Assist ADCNR in implementing State legislation that provides protection of Kral's water plantain (USFWS, 2014).

Conservation Measures and Best Management Practices:

- **RECOMMENDATIONS FOR FUTURE ACTIONS** We arranged the following recommendations for future conservation actions by general priority. 1. Gather baseline data on all populations and initiate long-term monitoring on sites, particularly on the secure, protected sites. 2. Develop habitat suitability indices using GIS to predict potential locations of additional populations. 3. Conduct additional field surveys to locate additional populations. 4. Since the discovery of the Hatchet Creek population,

conduct new surveys in the Piedmont Region. 5. Work to obtain protection for sites adjacent to privately owned lands. 6. Assess the threat of increased off-road vehicle use in stream channels with Kral's waterplantain occurrence. 7. Implement tasks identified in the recovery plan, except for number 6, related to reintroduction of the plant. 8. Assist ADCNR in implementing State legislation that provides protection of Kral's water-plantain. 9. Revise recovery plan to address changes in known distribution. (USFWS, 2020)

References

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

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/speciesProfile/>. Accessed April 2016.

U.S. Fish and Wildlife Service. 2014. Kral's Water-Plantain (*Sagittaria secundifolia*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama

USFWS. 2020. Kral's Water-Plantain (*Sagittaria secundifolia*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 16 pp.

U.S. Fish and Wildlife Service. 2014. Kral's Water-Plantain (*Sagittaria secundifolia*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office Daphne, Alabama.

U.S. Fish and Wildlife Service. 2014. Kral's Water-Plantain (*Sagittaria secundifolia*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Alabama Ecological Services Field Office, Daphne, Alabama.

SPECIES ACCOUNT: *Sisyrinchium dichotomum* (White irisette)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/28/1991; Southeast Region (R4)

Physical Description

A perennial herb, 26 to 40 centimeters (cm) tall. Stems are winged, 2.0 to 3.6 millimeters (mm) wide and about one-half the height of the plant (11 to 20 cm). There are three to five nodes, with successively shorter internodes between dichotomous branches. Basal leaves are one-third to one-half the height of the plant (11 to 19 cm long and 2.2 to 3.6 mm wide). Stem leaves are as broad or broader than the stem (9 to 14 cm long and 2.8 to 5.0 mm wide) and long-attenuate, with an acuminate apex. There are one to three winged peduncles per node (4 to 7 cm long and 0.7 to 0.9 mm wide). Tepals are 7.5 mm long and are white and recurved. Capsules are mostly globose (2.1 to 3.1 mm long and 2.4 to 3.2 mm wide). Seeds are black, rugulose, globose to elliptical, and 1.0 to 3.0 mm in diameter: only three to six seeds are contained in each capsule. The chromosome number is $2n = 32$. The flowering period is from late May through July (Hornberger 1987). White irisette branches from the first node, with plant parts becoming noticeably smaller and smaller. (USFWS, 1995)

Taxonomy

White irisette is 1 of 37 species of the genus *Sisyrinchium* and has the most restricted range of all species in the genus in the Southeastern United States (Hornberger 1987; A. Cholewa, University of Minnesota. personal communication, 1993) (USFWS, 1995).

Historical Range

No information available. (USFWS, 1995)

Current Range

Species populations are found in North Carolina counties (Burke, Henderson, Polk, and Rutherford) and Greenville County, South Carolina. (USFWS, 2019)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Breeding Season

Adult: Flowers and fruits from late May to July (NatureServe, 2015).

Reproduction Narrative

Adult: Flowers and fruits from late May to July. Relatively small number of seeds produced despite even small plants producing flowers (NatureServe, 2015).

Habitat Type

Adult: Dry-mesic forest (USFWS, 1995)

Environmental Specificity

Adult: Very narrow to narrow. (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 1995 and NatureServe, 2015)

Site Fidelity

Adult: High (inferred from USFWS, 1995 and NatureServe, 2015)

Habitat Narrative

Adult: This rare herb is typically found in open, dry to mesic oak-hickory forests on mid-elevation mountain slopes and on open, disturbed sites, such as woodland edges and roadsides (USFWS, 1995). Rich, basic soils in clearings and near the edges of upland woods where the canopy cover is thin. Often in places where the humus or mineral soil layers have been exposed by downslope runoff, which has removed the litter layer from the soil's surface. In the past, the thin canopy cover (and possibly the thin litter layer as well) was maintained by periodic fires and by native grazing animals. Now, most populations are in artificially disturbed areas, such as power line and road rights-of-way. High ecological integrity of the community and high site fidelity, as well as low tolerance range are inferred based on specific habitat needs and relatively low number of populations (USFWS, 2016)

Dispersal/Migration**Dispersal**

Adult: Unknown (USFWS, 1995)

Population Information and Trends**Population Trends:**

Stable (inferred from USFWS, 2019)

Species Trends:

Stable (inferred from USFWS, 2019)

Number of Populations:

15 (92 subpopulations) (USFWS, 2024)

Population Size:

92 sub-populations, ranging from 1 to 670 clumps in size, with a median value of 11 clumps per sub-population (USFWS, 2024)

Population Narrative:

The recovery plan references a total of seven populations, distributed across Polk and Rutherford Counties in North Carolina and adjacent Greenville County, South Carolina. As of this review, there are a total of 13 extant populations distributed across four North Carolina counties (Burke, Henderson, Polk, and Rutherford) and Greenville County, South Carolina. Thus, two North Carolina counties (Burke and Henderson) have been added to the known range of S.

dichotomum since the recovery plan was finalized. The county-level distribution of *S. dichotomum* in South Carolina has not changed. Four of the 13 extant populations consist of a single discrete location (Figure B.1; Table B.1). Of the remaining nine populations, the Worlds Edge/Sugarloaf Mountain population is the most extensive, consisting of some 55-58 spatially discrete locations and straddling the boundary where three North Carolina counties meet (Henderson, Polk and Rutherford). Fortunately, the majority of this population is now protected as one of the more recently acquired North Carolina State Parks (Chimney Rock State Park). In terms of overall spatial extent, the next largest populations are the Whiteoak/Chestnut/Miller Mountains population in Polk County, NC; the Melrose Mountain population, straddling the boundaries of Polk County, NC and Greenville County, SC; and the South Mountains (Yellowtop/Biggerstack/Middle Mountains) population in Rutherford County, NC (USFWS, 2019). At the time the species was listed, four populations of white irisette were known to still exist in Polk and Rutherford counties, NC. As of 2023, white irisette has 15 populations comprised of 92 sub-populations, ranging from 1 to 670 clumps in size, with a median value of 11 clumps per sub-population (USFWS, 2024).

Threats and Stressors

Stressor: Drought (USFWS, 2013)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Drought has been implicated in numerous population declines. The relative importance of this threat needs further investigation so that site-specific management objectives can be established; management actions implemented; and progress toward meeting these objectives evaluated. Drought is less likely to have straight-forward or practical management solutions, but nonetheless threaten the continued survival of *S. dichotomum*. However, one species expert's observations over many years suggest that *S. dichotomum* exhibits varied levels of susceptibility to drought across its range, with some buffering afforded by deeper soils (Rayner pers. comm. 2010). Observations such as this could prove valuable in the development of land protection strategies geared toward those areas in which *S. dichotomum* is more likely to be resilient to this threat. (USFWS, 2013)

Stressor: Invasive exotic species (USFWS, 2019)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: As noted in the 2013 5-year review, there is still a need to assess the severity and extent of invasive, exotic plant species in *Sisyrinchium dichotomum* populations throughout the range and determine the effectiveness of management strategies (Service 2013). The NCPCP has experimented with the use of a leaf blower to remove leaf litter in occupied and surrounding suitable habitat (NCPCP 2017). Response to this management activity remains unknown until further monitoring can be conducted at the site. The NCPCP is also pursuing prescribed burning at the White Oak Mountain and Melrose Mountain plant preserves; however, no burning has taken place to date (Starke 2019, NCPCP, personal communication). At the South Mountains Game Lands, a portion of the Silver Creek/Little Huckleberry Mountain population has been burned by prescribed fire four times (2005, 2008, 2011, and 2017) (Simon 2019, retired WRC, personal communication). Monitoring indicated an increase in population size between 2005 and

2008 (NCNGP 2018); however, additional monitoring has not occurred at the site. Findings of follow-up monitoring at the South Mountains Game Lands and the plant preserves will inform future management strategies at sites containing *Sisyrinchium dichotomum* and suitable habitat. (USFWS, 2019)

Stressor: Residential development (USFWS, 2013)

Exposure:

Response:

Consequence: Loss of habitat/loss of individuals

Narrative: *S. dichotomum* occurs on forested, steep mountain slopes and often in greater densities along the old earthen roadbeds; jeep, logging and hiking trails; and even some gravel road corridors that meander through these habitats. As these forested slopes are targeted for residential development, these winding roads and trails are often upgraded (widened, straightened and/or paved) to accommodate increased traffic volumes. An example of this threat occurred in 2006-2008, when the NCDOT widened and paved Skyuka Mountain Road in Polk County, North Carolina. Skyuka Mountain Road bisects a significant portion of the Whiteoak / Chestnut / Miller Mountain population of *S. dichotomum*, described as the largest population of the species (at over 1,000 plants) in the listing rule (56 FR 48752). (USFWS, 2013)

Stressor: Road widening and paving (USFWS, 2013)

Exposure:

Response:

Consequence: Loss of habitat/loss of individuals

Narrative: The Skyuka Mountain Road construction project was subject to ESA Section 7 consultation (USFWS in litt. 2006). At the conclusion of formal consultation (in 2006), NCDOT estimated that 25% of all plants located within 10 feet of the road edge, were expected to incur direct impacts from the road improvement project (Burroughs pers. comm. 2010). The NCDOT removed 943 plants from the construction footprint due to anticipated direct and adverse impacts (Burroughs in litt. 2010b). As of 2010, NCDOT was reporting more than 55% mortality within permanent plots established to monitor the survival of plants relocated out of the construction footprint. Although NCDOT's formal monitoring does not allow for a robust comparison of survivorship among relocated and non-relocated plants, NCDOT personnel are of the opinion that transplants exhibited considerably higher mortality than resident (non-relocated) plants during this time period (Burroughs pers. comm. 2010). Further illustrating the limitations of transplanting as a minimization strategy, NCDOT personnel have expressed concerns that seeds from the invasive exotic *Microstegium vimenium* may have been moved along with some of the *S. dichotomum* plants transplanted out of the road corridor (Burroughs pers. comm. 2010; Anderson, pers. comm. 2010). The preliminary findings illustrate that transplanting may not be an effective means of off-setting adverse effects from development or other infrastructure projects. Pursuant to the conservation measures pledged by NCDOT for the Skyuka Road project, plants located within the 138 permanent monitoring plots were monitored again in 2012. In these plots, there was a decrease in the overall number of plants (Herman pers. comm. 2013). The NCDOT also monitored portions of the roadside population not expected to be directly impacted from construction activities, in the same set of plots used to provide a baseline estimate in 2008. The number of plants in these plots remained stable between 2008 and 2012 (Herman pers. comm. 2013). (USFWS, 2013)

Stressor: Utility corridor construction (USFWS, 2013)

Exposure:**Response:****Consequence:** Loss of habitat

Narrative: Although densities of *S. dichotomum* may initially be higher along these corridors than in adjacent forests, the direct, indirect and cumulative effects of residential development, road upgrades and utility construction renders suitable habitat for *S. dichotomum* increasingly fragmented, less abundant, and less suitable over time (USFWS, 2013).

Stressor: Lack of natural disturbance (USFWS, 2013)**Exposure:****Response:****Consequence:** Loss of habitat

Narrative: The fact that *S. dichotomum* is frequently encountered along old road beds and jeep trails suggests the species is associated with disturbance. This is corroborated by available monitoring data which indicates that mortality is higher in deeper soils and accumulated leaf litter, habitats also correlated with smaller plant size (Burroughs in litt. 2010a, Rayner pers. comm. 2010). The particular disturbance regimes which tend to favor the persistence and spread of *S. dichotomum* are largely unknown, although fire is increasingly being looked to as either a missing natural disturbance mechanism, or an effective surrogate for such (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)**Exposure:****Response:****Consequence:** Loss of habitat

Narrative: Accelerated climate change is likely to further exacerbate certain threats, such as drought or the establishment and spread of invasive exotic plant species (USFWS, 2013).

Stressor: Disease or predation (USFWS, 2019)**Exposure:****Response:****Consequence:**

Narrative: Rayner and Gwinn (2014) investigated invasive, epigeic (non-burrowing) earthworms as a possible cause of *Sisyrinchium dichotomum* decline within the Chestnut Ridge population in Greenville County. They conducted a pilot study of the ingestion/digestion of seeds by the earthworms found on site. Epigeic earthworms ingested and digested significantly more seeds than anecic (burrowing) earthworms; however, epigeic earthworms liquefied within two days of ingestion, indicating seed toxicity. Rayner and Gwinn (2014) also found a significant correlation between plant condition and soil depth with deeper soils supporting plants in better condition. The humus layer around all plants was lacking and worm castings were present. Additional studies are planned to further investigate the relationship between *Sisyrinchium dichotomum* decline and invasive epigeic earthworms. Rayner and Gwinn (2014) have hypothesized that epigeic earthworms negatively affect seed germination and establishment, along with overall plant condition, by rapidly consuming the humus layer in soil and selectively removing seeds from the seed bank. (USFWS, 2019)

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2013)**Exposure:****Response:**

Consequence:

Narrative: The North Carolina Plant Conservation and Protection Act (NC State Code Article 19B, § 106-202.12) provides limited protection from unauthorized collection and trade of plants 15 listed under that statute. However, this statute does not protect the species or its habitat from destruction in conjunction with development projects or otherwise legal activities. Plant species are afforded even less protection in South Carolina, where they are protected only from disturbance where they occur on those properties owned by the state and specifically managed as South Carolina Heritage Preserves (SC State Code of Regulations Part 123 § 200-204). There are no other federal or state statutes that afford significant protections to *S. dichotomum*. (USFWS, 2013)

Stressor: Electric transmission right of way maintenance (USFWS, 2024)

Exposure:**Response:****Consequence:**

Narrative: Recent surveys indicated that electric transmission right of way maintenance via herbicide spraying and vegetation clearing is a threat (USFWS, 2024).

Recovery**Reclassification Criteria:**

Not defined. (USFWS, 1995)

Recovery Priority Number: 5C

Delisting Criteria:

1. When it has been documented that at least nine self-sustaining populations exist and that necessary management actions have been undertaken by the landowners or cooperating agencies to ensure their continued survival (USFWS, 1995).
2. When all of the above populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (USFWS, 1995).

Recovery Actions:

- 1. Protect existing populations and essential habitat. Only seven populations of white irisette are currently known to exist, all within two counties in North Carolina and one county of South Carolina. Until more is known about the species' biology, genetic diversity, and specific habitat requirements and about the measures necessary to protect the integrity of occupied sites, all existing populations should be protected. The long-term survival of nine populations is believed to be essential to the recovery of the species as a whole. (USFWS, 1995)
- 2. Determine and implement the management necessary for long-term reDroduction. establishment. maintenance, and vigor. Protection of the species' habitat is the obvious first step in ensuring its long-term survival, but this alone may not be sufficient. Habitat management may be necessary to allow the species to perpetuate its life cycle over the long term. However, because very little is known about this species, information about its genetic diversity, population biology, and ecology is necessary before effective management

- guidelines can be formulated and implemented. (USFWS, 1995)
- 3. Maintain and expand cultivated sources for the species and provide for the long-term maintenance of selected populations in cultivation. Maintaining the genotypes of small, isolated populations in cultivation should be of high priority. Seed or vegetative propagules should be collected as soon as possible from all populations that are still healthy enough to tolerate such harvest. A ready source of cultivated material should ease the threat of taking from wild populations. (USFWS, 1995)
 - 4. Enforce laws protecting the species and/or its habitat White irisette is not currently known to be a part of the horticultural trade, but this could become a threat in the future. The Endangered Species Act prohibits the taking of species from Federal lands without a permit and regulates trade. Section 7 of the Act provides additional protection to the habitat from impacts related to federally funded or authorized projects. In addition, for listed plants, the 1988 amendments to the Act prohibit: (1) their malicious damage or destruction on Federal lands and (2) their removal, cutting, digging up, or damaging or destroying in knowing violation of any State law or regulation, including State criminal trespass law. White irisette is listed as endangered in North Carolina. where State law prohibits the taking of the species without a permit and the landowner's written permission and regulates trade in the species (North Carolina State Statute 19-B, 202.12-202.19). The State of South Carolina lists the species but has not assigned a status. However, South Carolina does not offer legal protection to State-listed plants (Pittman. personal communication, 1993). These statutes focus on regulating, not preventing, trade in endangered and threatened species and on reducing the threat to wild populations from illicit collectors. It is currently not known whether white irisette is difficult to raise from seed. However, the possibility of establishing propagation programs and dispersing cultivated stock to botanical gardens and nurseries should be investigated. This could ease the threat of taking from wild populations. (USFWS, 1995)
 - 5. Develop materials to inform the Public about the status of the species and the recovery plan objectives. Public support for the conservation of white irisette could play an important part in encouraging landowner assistance and conservation efforts. This is especially true for the populations that occur in areas being adversely affected by residential development. Information materials should not identify the plant's locations so as not to increase the threat of taking. Information materials should indicate that cultivation is being carried out by the Center for Plant Conservation, so local gardeners need not think they could help by collecting the already limited amount of seed. (USFWS, 1995)
 - 6. Annually assess the success of recovery efforts for the species. Review of new information, evaluation of ongoing actions, and redirection, if necessary, are essential for assuring that full recovery is achieved as quickly and efficiently as possible. (USFWS, 1995)
 - Assess the current condition and extent of known populations; work with partners to standardize the mapping and assessment of populations (and subpopulations); and iteratively assess protection priorities in light of the relative importance of known populations (USFWS, 2013).
 - Work with landowners to develop standardized methods of counting and mapping their populations (using Rayner's protocols where feasible), so that a baseline can be established for evaluating trends, vulnerability to threats (such as invasive exotic plant species), and responses to management (such as prescribed fire and/or efforts to control invasive exotic plant species). (USFWS, 2013).

- The two existing recovery criteria (for de-listing) are largely redundant; establish criteria that are more specific, objective, and measurable. Establish down-listing criteria (for reclassification from endangered to threatened). (USFWS, 2013)
- Conduct surveys beyond the extent of known populations, to determine the true extent of the known range of the species. (USFWS, 2013)
- Work with landowners, managers and others to expand the scope of monitoring (using Rayner's protocol, where feasible) to additional populations in North Carolina. (USFWS, 2013)
- Locate and pursue analysis of genetic tissue samples collected by Rayner in 2001. (USFWS, 2013)
- Work with partners to investigate/research management strategies that will minimize or eliminate threats to the species with regards to invasive, exotic plant management and leaf litter accumulation. (USFWS, 2019)
- Work with partners to investigate/research the impact invasive, epigeic earthworms may be having on *Sisyrinchium dichotomum* and suitable habitat. (USFWS, 2019)
- Discontinue the use of direct plant relocations as a method of minimizing impacts to the species from development projects until more information is known about what makes a relocation successful. Work with partners to conduct research into transplant methods and post-transplant management. (USFWS, 2019)
- Work with partners and/or botanical gardens to determine seed germination requirements and rate of seed viability. Develop a plan for conserving the species in ex situ collections – either through conservation gardens or seed banking. (USFWS, 2019)
- Work with partners to conduct a range-wide census of all populations. (USFWS, 2019)

Conservation Measures and Best Management Practices:

- **RECOMMENDED FUTURE ACTIVITIES** The 2013 and 2019 five-year reviews included a list of recommendations for recovery of the species. Recommended future activities are as follows: • Work with partners to investigate management strategies that will minimize or eliminate threats to the species with regards to invasive, exotic plant management and leaf litter accumulation. • Work with partners to investigate the impact invasive, epigeic earthworms may be having on *Sisyrinchium dichotomum* and suitable habitat. • Work with partners and/or botanical gardens to determine seed germination requirements and rate of seed viability. Develop a plan for conserving the species in ex situ collections – either through conservation gardens or seed banking. • Work with partners to conduct a range-wide census of all populations at least every five years. • Collaborate with partners to determine how climate change would impact the resiliency of white irisette populations. • Work with partners to identify gaps in management knowledge. • Quantify threats and protection priority of all sub-populations. • Collaborate with partners to establish demographic plots to estimate population growth rates to determine if some populations meet the criteria of self-sustaining (USFWS, 2024).

References

USFWS. 2019. White irisette (*Sisyrinchium dichotomum*)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Asheville Ecological Services Field Office. 41 pp. July 29, 2019. https://ecos.fws.gov/docs/five_year_review/doc6085.pdf

USFWS. 1995. Recovery Plan for White Irisette (*Sisyrinchium dichotomum*) Bicknell. U.S. Fish and Wildlife Service, Atlanta, Georgia. 22 pp

USFWS. 2013. White irisette (*Sisyrinchium dichotomum*)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Asheville Ecological Services Field Office. 26 pp. May 3, 2013. https://ecos.fws.gov/docs/five_year_review/doc4148.pdf

USFWS. 1995. Recovery Plan for White Irisette (*Sisyrinchium dichotomum*) Bicknell. U.S. Fish and Wildlife Service, Atlanta, Georgia. 22 pp. Link

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Asheville Ecological Services Field Office. 41 pp. July 29, 2019. https://ecos.fws.gov/docs/five_year_review/doc6085.pdf .

USFWS. 2024. White Irisette (*Sisyrinchium dichotomum*) 5- Year Status Review: Summary and Evaluation. Southeast Region. Asheville Ecological Services Field Office. Asheville, North Carolina. 9 pp.

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Asheville Ecological Services Field Office. 26 pp. May 3, 2013. https://ecos.fws.gov/docs/five_year_review/doc4148.pdf

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Asheville Ecological Services Field Office. 41 pp. July 29, 2019. https://ecos.fws.gov/docs/five_year_review/doc6085.pdf

USFWS. 2024. White Irisette (*Sisyrinchium dichotomum*) 5- Year Status Review: Summary and Evaluation. Southeast Region. Asheville Ecological Services Field Office. Asheville, North Carolina. 9 pp.

USFWS. 1995. Recovery Plan for White Irisette (*Sisyrinchium dichotomum*) Bicknell. U.S. Fish and Wildlife Service, Atlanta, Georgia. 22 pp.

SPECIES ACCOUNT: *Spiranthes delitescens* (Canelo Hills ladies'-tresses)

Species Taxonomic and Listing Information

Listing Status: Endangered; 1-06-1997; Southwest Region (R2)

Physical Description

Spiranthes delitescens is a slender, erect, terrestrial orchid that, when in flower, reaches approximately 50 centimeters (cm) (20 inches (in.)) tall. Five to 10, linear-lanceolate, grass-like leaves, 18 cm (7.1 in.) long and 1.5 cm (0.6 in.) wide, grow basally on the stem. The fleshy, swollen roots are approximately 5 mm (0.2 in.) in diameter. The top of the flower stalk contains up to 40 small white flowers arranged in a spiral. This species is presumed to be perennial, but mature plants rarely flower in consecutive years and, in some years, have no visible above ground structures (McClaran and Sundt 1992, Newman 1991).

Taxonomy

Martin first collected *Spiranthes delitescens* in 1968 at a site in Santa Cruz County, Arizona (Sheviak 1990). This specimen was initially identified as *Spiranthes graminea*, a related Mexican species. Sheviak (1990) found that the *Spiranthes* specimens in Arizona, previously thought to be *S. graminea*, displayed a distinct set of morphological and cytological characteristics and named them *S. delitescens*.

Historical Range

Unknown.

Current Range

The current range of CHLT includes populations in four ciénegas in southern Arizona, three of which are in Santa Cruz County and the fourth in Cochise County (Figure 3.1). The populations range in elevation from 1,402 to 1,508 m (4,600 to 4,950 ft), and the total ciénega size for each population is small: Babocomari is approximately 61 hectares (ha; 151 acres (ac)), Canelo Hills (including both subpopulations) is approximately 10 ha (24 ac), San Rafael Valley is approximately 7 ha (17 ac), and Turkey Creek is approximately 19 ha (48 ac). (USFWS, 2021)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Food Source

Adult: Dependent upon mycorrhizal relationship with fungus for part or all of its nourishment.

Food/Nutrient Narrative

Adult: Mycorrhizal fungi are required to supply the *S. delitescens* embryo with needed enzymes and nutrients early in the growth of the seedling; minerals, vitamins and an available organic carbon source are essential to the development of the plant (Stoutamire 1974; Luer 1975; Dressler 1981). The species-specificity of the fungi-orchid symbiosis is ambiguous and is thought

to decrease as the plant ages (Warcup 1975). The association with a Basidiomycete fungi is thought to range from 1 to 15 years before the first leaf emerges (McClaran and Sundt 1992). Several different species of fungi are associated with most roots, and taxonomic relationships between fungi and orchid species appear to exist (Warcup 1975; Dressler 1981). Environmental conditions will affect the fungi-orchid relationship; high levels of nitrogen and low soil pH may reduce the likelihood of fungal penetration into the seed, thus decreasing the germination rate (Warcup 1975).

Reproductive Strategy

Adult: Self-pollinator

Lifespan

Adult: 23 to 67 years; mean expected life is 53 years

Dependency on Other Individuals or Species

Adult: The species is totally parasitic upon fungus for germination and early growth stages. Bees are the primary pollinator for *Spiranthes*, with *Bombus* being the most common genus; other pollinating organisms include flies, moths, and butterflies (van der Pijl and Dodson 1966; Dressler 1981). (NatureServe 2015).

Breeding Season

Adult: The inconspicuous plants are visible July and August when the roughly 20 cm tall inflorescences develop (P. Sundt, pers. comm. 23 Jan. 1990; The Nature Conservancy Arizona Field Office, pers. comm.). The fruits mature approximately three weeks after the flowers form, usually during the end of August, releasing hundreds of tiny seeds from each capsule to be dispersed, probably via the wind (McClaran and Sundt 1992; P. Sundt, pers. comm. 23 Jan. 1990).

Key Resources Needed for Breeding

Adult: *Spiranthes delitescens* will not bloom in dry years when precipitation levels are atypically low (B. Jennings, pers. comm. 25 Jan. 1990).

Reproduction Narrative

Adult: Bees are the primary pollinator for *Spiranthes*, with *Bombus* being the most common genus; other pollinating organisms include flies, moths, and butterflies (van der Pijl and Dodson 1966; Dressler 1981). Within 3 days of successful pollination, *Spiranthes* flowers dehydrate and become discolored (Catling 1982). Orchid flowers have a unique morphology which has coevolved with their pollinators (van der Pijl and Dodson 1966). As with most terrestrial orchids, successful seedling establishment probably depends on the successful formation of endomycorrhizae (a symbiotic association between plant root tissue and fungi) (McClaran and Sundt 1992). The time needed for subterranean structures to produce above ground growth is unknown. Plants may remain in a dormant, subterranean state or remain vegetative (nonflowering) for more than one consecutive year. Plants that flower one year can become dormant, vegetative, or reproductive the next year (McClaran and Sundt 1992, Newman 1991). The saprophytic/ autotrophic state of orchid plants may be determined by climatic fluctuations and edaphic factors, such as pH, temperature, and soil moisture (Sheviak 1990). Some orchids are self-fertile, but most often fertilization is the result of outcrossing. Self-pollination is advantageous when plants have extended their range into areas not previously inhabited by the

species (Dressler 1981). *Spiranthes* are often self-fertilized, and individuals that require cross-pollination are receptive for only 10 to 40 days (Catling 1982). Flowers older than 40 days contain dead ovules (Catling 1982). Within 3 weeks of pollination the seeds are fully developed and the ovary splits. Orchids easily hybridize; both inter-specific and inter-generic hybrids occur in the wild (Sanford 1974). In dry climates, flowering often occurs during the rainy season. Flowering of the *Spiranthes* occurs in July, when temperatures range from 60 F at night to 100 F during the day and when the majority of the year's 15 to 20 inches of precipitation falls (Merrigan 1990; The Nature Conservancy Arizona Field Office, pers. comm.). In some cases too much rain, possibly causing a decrease in pollinator activity, results in a decrease in the number of flowers and consequently the number of fruits (Dressler 1981). Most nontropical species release their seeds in the fall at the beginning of the dormant period (Dressler 1981). In addition to moisture dependency, flowering of some species of *Spiranthes* is photoperiodically induced (Catling 1982). The age of sexual maturity is dependent on the species and can range from several years to over twenty years (Stoutamire 1974; B. Jennings, pers. comm. 25 Jan. 1990). Inflorescences first develop in *Spiranthes spiralis* thirteen to fifteen years after seed germination (Wells 1981). Once reproductively mature, the age of the plant is not a factor in flowering, whereas temperature and precipitation appear to be significantly related to the percentage of flowering plants (Wells 1981). *Spiranthes diluvialis* will not bloom in dry years when precipitation levels are atypically low (B. Jennings, pers. comm. 25 Jan. 1990). *S. spiralis* plants which have reverted back to the saprophytic stage are capable of flowering during the initial year of resuming above-ground growth (Wells 1967). The average percentage of flowering *S. spiralis* plants over a thirteen year period was 33, ranging from 73% in 1966, 19% in 1970, 43% in 1973, down to 1% after the 1976 drought, and recovering to 31% the following year (Wells 1981). The grass-like leaves of the orchid, growing low in the sedge and horsetail fields, are difficult to see for most of the year. The inconspicuous plants are visible July and August when the roughly 20 cm tall inflorescences develop (P. Sundt, pers. comm. 23 Jan. 1990; The Nature Conservancy Arizona Field Office, pers. comm.). The fruits mature approximately three weeks after the flowers form, usually during the end of August, releasing hundreds of tiny seeds from each capsule to be dispersed, probably via the wind (McClaran and Sundt 1992; P. Sundt, pers. comm. 23 Jan. 1990). Many inflorescences are damaged during the summer; Sundt (pers. comm. 23 Jan. 1990) feels that grasshoppers may be responsible for the broken stalks and the chewed capsules. The life-cycle of the plants is unclear. Most likely these orchids are perennial; however, no dormant underground structures have been identified (McClaran and Sundt 1992). Determining the over-wintering structure is difficult without disturbing the plants. The plant may remain below-ground most of the year or, common to many *Spiranthes*, small, inconspicuous leaf rosettes may grow throughout the cool months, hidden by the tall vegetation (McClaran and Sundt 1992; B. Jennings, pers. comm. 25 Jan. 1990). In February, an inspection of approximately 40 flagged areas (presumably indicating the previous year's orchids) revealed no above-ground orchid structures (Newman 1990). Plants rarely flower in consecutive years and the relationship between the flowering plants cannot be elucidated since the growth pattern of the subterranean structures is unknown (McClaran and Sundt 1992).

Habitat Type

Adult: The four populations of *Spiranthes delitescens* occur above in marshy meadows, seeps and hummocks.

Habitat Vegetation or Surface Water Classification

Adult: Estuarine: Herbaceous wetland; Palustrine: Bog/fen; Terrestrial: Desert, Grassland/herbaceous, Woodland-Hardwood

Dependencies on Specific Environmental Elements

Adult: Narrow pH tolerance, specific temperature and moisture requirements of the fungi-orchid association

Environmental Specificity

Adult: Very narrow (NatureServe 2015); specialist or community with key requirements scarce.

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Habitat Narrative

Adult: Plants occur intermixed with tall grasses and sedges at an elevation of approximately 1,524 m (5,000 ft). All *Spiranthes* populations occur where scouring floods are very unlikely (Newman 1991). Soils supporting the populations are finely grained, highly organic, and seasonally or perennially saturated. Springs are the primary water source, but a creek near one locality contributes near-surface groundwater (McClaran and Sundt 1992). Cienegas (mid-elevation wetland communities) at about 1525 m elevation. Soils are highly organic and seasonally or continuously water-saturated. The dominant vegetation in the cienegas near the *Spiranthes* include grasses, sedges (*Carex* spp.), rushes (*Juncus* spp.), spike-rush (*Eleocharis* spp.), cat-tails (*Typha* spp.), and horsetails (*Equisetum* spp.) (Grater 1973, Merrigan 1990, The Nature Conservancy Arizona Field Office, pers. comm.).

Dispersal/Migration**Motility/Mobility**

Adult: Low

Dispersal

Adult: Low/slow

Population Information and Trends**Resiliency:**

Resiliency is met by having enough individuals within populations to withstand disturbances such as random fluctuations in germination rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities. Little is known regarding the numbers of plants required to achieve resilient CHLT populations; however, in general having more individuals across populations will provide greater resiliency. Greater resiliency will enable the species to better withstand the effects of its various threats and increase the likelihood of species viability. Our current understanding of the species, as well as minimum rare plant population sizes called for in the literature, suggest that our Downlisting and Delisting Recovery Criteria 1 (minimums of 100 and 650 individuals and multiple

subpopulations) is sufficient to achieve resilient CHLT populations. (USFWS, 2022)

Representation:

Representation is met by maintaining sufficient genetic diversity across the geographic distribution of CHLT. We do not have genetic information about CHLT; however, the recovery criteria are designed to promote genetic exchange through pollen transfer among subpopulations and populations. Additional research into genetic isolation and hybridization is warranted. Ecological diversity can potentially be increased through the establishment of new populations at strategic sites that have slightly different temperatures, precipitation, water sources, slope, soils, and vegetation community; however, all ciénegas will be at roughly the same elevation and within the same geographic range. (USFWS, 2022)

Redundancy:

Redundancy is met by having multiple populations distributed across the species' range. Because plants in populations are separated from plants in other populations, they are less likely to be simultaneously affected by catastrophic events (e.g., high severity fire) or locally important events (e.g., intense flooding). Therefore, the species will be more likely to withstand such events, reducing the risk of extinction. The down- and delisting criteria require a minimum of seven populations distributed across the range of the species. (USFWS, 2022)

Population Growth Rate:

Slow

Number of Populations:

4 (USFWS, 2021)

Population Size:

Unknown

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Adaptability:

Low

Population Narrative:

All four populations have been monitored periodically. The largest number of plants seen in any population was 731, in 1999 at the San Rafael Valley Population; the smallest number of plants found was 3, in 2019 in the Turkey Creek Population. The species requires saturated organic soils in ciénegas, an appropriate mycorrhizal symbiont, groundwater and precipitation, disturbance to remove competition with native and nonnative plant associates, and suitable pollinator presence. (USFWS, 2021)

Threats and Stressors

Stressor: Competition from native and non-native invasive plants

Exposure: Not assessed; see narrative

Response: Not assessed; see narrative

Consequence: Not assessed; see narrative

Narrative: This species is threatened by competition from native and non-native invasive plants. According to the Arizona Fish and Game Department (2000), "possibly the greatest threat to the survivability and fecundity of the orchid is the dense vegetation surrounding the small orchid plants." The invasion of the exotic Johnson grass (*Sorghum halepense*) into the Canelo Hills Cienega and the aggressive growth of *Equisetum* spp. may exacerbate the problem (The Nature Conservancy Arizona Field Office, pers. comm.). Sedges and cattail may also compete with the orchid by forming mats that the orchid cannot grow through (AFGD 2000). McClaran and Sundt (1992) speculate that competition from neighboring plants for nutrients and sunlight may decrease the photosynthetic rate and the vigor of the *Spiranthes*. In addition, the lowered temperature and elevated moisture level of the soil may alter the growth rate of the orchid; more likely, this would directly affect the fungi-orchid association. Presumably (inferred from information on other terrestrial species), germination will not occur if the environmental conditions are not sufficient for mycorrhizal penetration into the newly dispersed seeds. Possibly, a specific environmental cue, such as high light intensity, is required to trigger a greater percentage of flowering plants than has been seen in recent years.

Stressor: Habitat degradation/loss

Exposure: Not assessed; see narrative

Response: Not assessed; see narrative

Consequence: Not assessed; see narrative

Narrative: The foreseeable threat with the greatest impact is habitat degradation/loss. Changes in the habitat in which an orchid is growing may be lethal, tolerable or beneficial to the survival of the plants, depending on the species of orchid. There is evidence that *Spiranthes delitescens* requires some disturbance (AFGD 2000). The alteration of the community structure may help maintain the specific parameters of the site required by the particular orchid species (Sanford 1974; Sheviak 1974; Dressler 1981). Species that tolerate disturbances may rely upon their saprophytic capabilities and, as long as the environmental conditions necessary for the fungi-orchid association are present, the plant may remain underground until the above-ground conditions are favorable for growth (Stoutamire 1974; Wells 1981). The population size of *Spiranthes* growing in areas where land is frequently disturbed (mowed, plowed, etc.) decreases when tall grasses or dense short grasses increase in abundance (Sanford 1974); any orchid species cannot compete with fast growing, large herbaceous plants. Other threats to *Spiranthes delitescens* include growing water demands and associated diversions and impoundments, uncontrolled livestock grazing as well as lack of grazing, sand and gravel mining, collection, and possibly fire suppression (AFGD 2000).

Stressor: herbivory or seed predation by vertebrates and invertebrates (USFWS, 2021a)

Exposure:

Response:

Consequence:

Narrative: Herbivory or seed predation by vertebrates or invertebrates during the flowering and fruiting season can impact CHLT reproduction. Herbivory has been shown to have great impact on individual populations in some years (Gori 1994, p. 2; Backer 1998, p. 4; Gori and Backer 1999, p. 1). Pollinator decline may impact CHLT, as its primary pollinator is thought to be the Sonoran

bumblebee (*Bombus sonorus*), a species that may also be at risk of decline (see Figure 1). Low numbers and limited distribution, which characterizes CHLT populations, reduce resiliency and increase risks to populations from all threats and limit recruitment and genetic diversity. Drought and climate change also result in further ciénega habitat loss or reduction. To date, conservation efforts include periodic monitoring, removal of invading trees at one location, and seed collection from a second location. (USFWS, 2021a)

Recovery

Reclassification Criteria:

Not developed.

Recovery Priority Number: 2C

Delisting Criteria:

Not developed.

Recovery Actions:

- Not developed.
- Possible effective management practices such as grazing, fires, and control of competing native and non-native plants have not been researched enough to determine the best practice or the best combination of practices.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS A Draft Recovery Plan for this species was completed in June 2021. This recovery plan includes recommendations for actions which increase the size and number of populations; establish exsitu plants and seed collections at botanical institutions; protect, restore, and manage functional habitat; reduce threats to CHLT and its habitat; and improve understanding of conditions, trends, and management, as well as geology, ecology, biology, genetics, and habitat restoration. (USFWS, 2021a)

References

USFWS 1997. Endangered and Threatened Wildlife and Plants. Determination of Endangered Status for Three Wetland Species Found in Southern Arizona and Northern Sonora, Mexico. Federal Register 62(3), January 6, 1997, 665-689

NatureServe 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://explorer.natureserve.org>. (Accessed: June 29, 2015). USFWS. 2021. Species status assessment report for Canelo Hills ladies'-tresses (*Spiranthes delitescens*). United States Fish and Wildlife Service Arizona Ecological Services Office, Tucson, Arizona. 90 pp.

NatureServe 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://explorer.natureserve.org>. (Accessed: June 29, 2015).

NatureServe 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://explorer.natureserve.org>. (Accessed: June 29, 2015). USFWS. 2021. Species status assessment report for Canelo Hills ladies'-tresses (*Spiranthes delitescens*). United States Fish and Wildlife Service Arizona Ecological Services Office, Tucson, Arizona. 90 pp. USFWS. 2022. Canelo Hills ladies'-tresses (*Spiranthes delitescens*) Final Recovery Plan. Southwest Region, Tucson, Arizona, USA. 26 pp.

NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://explorer.natureserve.org>. (Accessed: June 29, 2015).

USFWS. 1997. Endangered and Threatened Wildlife and Plants. Determination of Endangered Status for Three Wetland Species Found in Southern Arizona and Northern Sonora, Mexico. Federal Register 62(3), January 6, 1997, 665-689

USFWS. 2021a. Canelo Hills Ladies' Tresses (*Spiranthes delitescens*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Arizona Ecological Services Office Tucson, Arizona. 7 pp.

SPECIES ACCOUNT: *Spiranthes diluvialis* (Ute ladies'-tresses)

Species Taxonomic and Listing Information

Listing Status: Threatened; 01/17/1992; Mountain-Prairie Region (R6) (USFWS, 2016)

Physical Description

Ute ladies'-tresses was first described as a species in 1984 by Dr. Charles J. Sheviak from a population discovered near Golden, Colorado (Sheviak 1984). The species is a perennial orchid (member of the plant family Orchidaceae) that first emerges above ground as a rosette of thickened leaves that is very difficult to distinguish from other vegetation, especially given the dense herbaceous vegetation in which the species often grows. Its leaves are up to 1.5 cm (0.6 in.) wide and 28 cm (11 in.) long; the longest leaves are near the base. The usually solitary flowering stem is 20 to 50 cm (8 to 20 in.) tall, terminating in a spike of 3 to 15 white or ivory flowers. Flowering is generally from mid-July through August. However, in some locations it may bloom in early July or may still be in flower as late as early October. Ute ladies'-tresses looks most similar to hooded ladies'-tresses (*Spiranthes romanzoffina*), but differs in the detailed characteristics of the individual flowers. In hooded ladies'-tresses (which is more common), each individual flower has petals and sepals that are fused to form a covering, or "hood". In Ute ladies'-tresses, these floral parts are not fused, appearing instead to be widely spread, or "gaping" open.

Current Range

When it was listed under the Act in 1992, Ute ladies'-tresses was known from 10 extant populations within portions of only two states (Colorado and Utah, USFWS 1992a). At that time, these 10 populations were estimated to encompass approximately 170 ac of occupied habitat. At listing, the species was presumed extirpated in Nevada. Since listing, Ute ladies'-tresses was rediscovered in Nevada, and new populations were discovered in southern Idaho, southwestern Montana, western Nebraska, central and northern Washington, and southeastern Wyoming (Fertig et al. 2005, Figure 1 of this Biological Opinion), and south central British Columbia (Bjork 2007). In 2005, 53 populations (encompassing 674-784 ac of habitat) were considered extant across the range of the species (Fertig et al. 2005); the British Columbia locations were discovered the following year (Bjork 2007). Utah had the most populations (23), the largest amount of occupied habitat (234-308) ac, and the highest number of reported plants (47,859 individuals) of any state (Fertig et al. 2005). The Spanish Fork watershed in Utah was assessed as having the highest recorded population estimate (28,825 plants), whereas the Upper Green-Flaming Gorge Reservoir population (which spans the Colorado-Utah border) spanned the most extensive area (117-126 ac). The majority of known populations (66 percent) occupied between 0.1 and 10 ac, whereas relatively few (4.9 percent) occupied more than 50 ac.

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Key Resources Needed for Breeding

Adult: Pollinators: Mainly bees (USFWS, 2023)

Reproduction Narrative

Adult: Flowering is generally from mid-July through August. However, in some locations it may bloom in early July or may still be in flower as late as early October. Ute ladies'-tresses is a perennial plant species that blooms in the late summer to early fall and requires pollinators, mainly native bees, for reproduction. Seeds are extremely small and easily spread by wind or water. The exact details of the Ute ladies'-tresses life cycle are not fully understood, but it can remain dormant underground for 11 or more years, and that it is likely dependent on symbiotic mycorrhizae during all life stages. In addition to mycorrhizae, individual plant survival and recruitment depends on the presence of adequate ground or surface water during the growing season, the presence of appropriate pollinators, and adequate sunlight for photosynthesis (USFWS, 2023)

Habitat Type

Adult: Ute ladies'-tresses occurs in a variety of human-modified and natural habitats, including, seasonally flooded river terraces, sub-irrigated or spring-fed abandoned stream channels and valleys, and lakeshores

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Ute ladies'-tresses occurs in a variety of human-modified and natural habitats, including, seasonally flooded river terraces, sub-irrigated or spring-fed abandoned stream channels and valleys, and lakeshores (Jennings 1989, USFWS 1992a, Fertig et al. 2005). Numerous populations also occur along irrigation canals, behind berms, within abandoned roadside borrow pits, along reservoir edges, and other human created or modified wetlands. Streamside populations of Ute ladies'-tresses typically occur on shallow alluvial soils overlying permeable cobbles, gravels, and sediments. Across the range of the species, populations occur at elevations ranging from 220 to 558 m (720 to 1,830 ft) in Washington and British Columbia to 2,134 m (7,000 ft) in northern Utah. Most Ute ladies'-tresses sites have mid-successional vegetation (well-established grasses and forbs) communities that are maintained by human disturbances such as livestock grazing, mowing, ditch and irrigation maintenance, prescribed fire (Allison 2001, Fertig et al. 2005). Ute ladies'-tresses may persist for some time in the grassy understory of woody riparian shrublands, but does not appear to thrive under these conditions (Ward and Naumann 1998). Nearly all streambank, floodplain, and abandoned ox-bow sites occupied by Ute ladies'-tresses have a high water table (usually within 12.5 to 45 centimeters (5 to 18 inches) of the surface) augmented by seasonal flooding, snowmelt, runoff, and often irrigation (Jennings 1989, Arft 1995, Black et al. 1999, Riedel 2002). Soils must be sufficiently stable and moist in the summer flowering season to support the species (Ward and Naumann 1998). Sites located in springs or sub-irrigated meadows appear to be fed by groundwater rather than surface flows; less is known about the average depths to groundwater in these locations, but it is reasonable to assume that (as with locations where groundwater depths have been quantified) groundwater must remain relatively close to the surface in order to sustain the moist soils consistently associated with Ute ladies'-tresses.

Dispersal/Migration

Population Information and Trends**Number of Populations:**

18 Extant AUs (USFWS, 2023)

Population Size:

~80,000

Population Narrative:

Ute ladies'-tresses is a long lived perennial herb that is thought to reproduce exclusively by seed (Fertig et al. 2005). Bees are the primary pollinators; however because Ute ladies'-tresses provides only nectar as a food reward, other pollen-providing plant species must be present to attract and maintain pollinators (Sipes and Tepedino 1995, Sipes et al. 1995, Pierson and Tepedino 2000). The life cycle of Ute ladies'-tresses consists of four main stages—seedling, dormant, vegetative, and reproductive (flowering or fruiting) (Fertig et al. 2005). Ute ladies'-tresses seedlings may develop slowly into larger, dormant mycorrhizal roots or grow directly into above ground vegetative shoots (Wells 1981), but neither has been confirmed in the wild. The Cincinnati Zoo and Botanical Garden has grown plants from seed under laboratory and greenhouse conditions; germination took 6-8 months and development from a protocorm into a plant was slow (Pence 2009). Long term demographic monitoring studies indicate that vegetative or reproductive Ute ladies'-tresses plants can revert to a below ground existence for as many as four consecutive growing seasons before reemerging above ground (Arft 1995, Allison 2001, Heidel 2001). Flowering individuals are necessary to reliably distinguish Ute ladies'-tresses from other similar-looking plant species (esp. other *Spiranthes* species), and surveys during flowering season also maximize the likelihood of detecting Ute ladies'-tresses among dense stands of other herbaceous plant species. However, surveys in which only flowering stems are tallied are of limited value for assessing population trends, given that individual Ute ladies'-tresses plants do not flower consistently from one year to the next, and the relative proportion of individual Ute ladies'-tresses plants in each of the four life stages (seedling, dormant, vegetative, reproductive) can vary widely within and among years and between different colonies (Arft 1995, Pierson and Tepedino 2000, Allison 2001, Heidel 2001, Fertig et al. 2005). Population trends are less variable when inferred from datasets in which all life stages are counted (Arft 1995, Heidel 2001). However, because non-reproductive individuals are inherently difficult and laborious to detect, most surveys tend to focus on the detection (and counting) of flowering individuals (Fertig et al. 2005). As a result, knowledge of Ute ladies'-tresses population trends is severely hindered; this also suggests that available estimates (derived solely from flowering stem counts) are likely to represent conservative estimates of total population size. With these and other caveats (discussed further in Fertig et al. 2005) in mind, the following statements can be made regarding rangewide abundance and trends in Ute ladies'-tresses: when the species was listed under the Act in 1992, the rangewide population was estimated to contain fewer than 6,000 individuals (USFWS 1992). In 1995, the draft recovery plan increased this estimate to 20,500 individuals, primarily the result of 21 new populations discovered over the previous 3 years (USFWS 1995). As of 2005, 53 populations were estimated to collectively contain more than 80,000 (83,316) individuals (Fertig et al. 2005). For these populations, available population estimates ranged in size from 1 to more than 28,000 plants. More than 80 percent of these populations contained fewer than 1,000 individuals; 38 percent contained fewer than 100 individuals. In summary, Ute ladies'-tresses occurs in more

than 50 populations distributed across 8 U.S. states and 1 Canadian province; these populations collectively contain some 80,000 individuals. Approximately 80 percent of known populations are associated with lands managed for agriculture or recreation, rivers regulated by dams, or other human-modified habitats (Fertig et al. 2005). Research, monitoring and management activities have demonstrated that ongoing patterns of land use across the range of the species are capable of mimicking or providing the conditions required for the species' persistence. At the time of listing in 1992, Ute ladies'-tresses was known to occur only in Utah and Colorado. Today, it is known to occur in eight states – Colorado, Idaho, Montana, Nebraska, Nevada, Utah, Washington, and Wyoming – as well as in southern British Columbia (Figure 1). We believe this expanded known range is primarily due to the increased survey effort that occurred after listing. We know of at least 71 historical occurrences spread across 19 watershed basins, at the 6-digit hydrological unit code (HUC) level (Figure 1). Due to the wide distribution and complex life history of the species, we used 6-digit HUC watershed basins as surrogates for populations, called analytical units (AUs), for the purposes of the SSA analysis (USFWS, 2023). Ute ladies'-tresses currently is extant in 18 out of 19 historical AUs (Table 2). The Upper Arkansas AU is considered extirpated due to the complete habitat destruction of the only known occurrence. Of the 18 extant AUs, 5 AUs currently have high resiliency, 8 have moderate resiliency, and 5 have low resiliency. (Table 2). The 18 AUs are distributed broadly across the species' historical range, and represent a variety of habitat types, environmental conditions, and ecological settings (Figure 2) and the species current level of redundancy reduces risk from stochastic and catastrophic events. Representation for the species is currently captured by the 18 AUs distributed across 12 different ecoregions with the species occurring within 7 habitat types, illustrating the species' potential to adapt to short- and long-term changes to environmental conditions, except for those novel changes that may eliminate wetland habitats, such as changes in the climate regime, water management, urbanization, and development (USFWS, 2023A).

Threats and Stressors

Stressor:

Exposure:

Response:

Consequence:

Narrative: At the time of listing, we identified habitat loss and modification as the primary threat to the species, but also noted that small population sizes and low reproductive rates rendered Ute ladies'-tresses vulnerable to other threats (USFWS 1992a). Our listing rule identified several specific forms of habitat loss and modification as threats to Ute ladies'-tresses, including: urbanization, water development and conversion of lands to agriculture, excessive livestock grazing, excessive or inappropriate use of herbicides or other chemicals, and the proliferation of invasive exotic plant species. In addition, we concluded that the species may be subject to over-collection, given its status as an orchid and inquiries from orchid enthusiasts and wildflower collectors. We characterized existing regulatory mechanisms as inadequate to ensure the long-term persistence of Ute ladies'-tresses, given these threats. Today, many of these same threats affect Ute ladies'-tresses at least at the site-specific level (Figure 2; Fertig et al. 2005), and some newer threats have emerged. For example, whereas over-collection had not materialized as a specific threat to Ute ladies'-tresses, vegetation succession and losses or reductions in pollinators appeared to be new threats (although they characterize pollinator availability as more of a potential threat). Current threats include competition from invasive species, vegetative succession, road and infrastructure construction, and changes in hydrology. Conversion of

irrigation water to municipal use, flood control (includes riverbank stabilization), water development or redevelopment, and restoration projects targeting stream and riparian corridors (includes in-stream and habitat alteration) contribute to altered hydrologic regimes across the species' range. However, Ute ladies'-tresses has proliferated in areas with greatly altered, but stable and predictable hydrology (Fertig et al. 2005). Prominent examples include the Green River along the Colorado-Utah border (Ward and Naumann 1998); Diamond Fork Creek in the Spanish Fork watershed of Utah (Black and Gruwell 2004); the Columbia River in Washington (Cordell-Stine and Pope 2008); and the South Fork Snake River in Idaho (Idaho Conservation Data Center 2007). The species is also frequently encountered along streams and canals and in wet hay pastures in the Uinta Basin of eastern Utah, even though an extensive irrigation canal system was constructed in the early 1900s and natural streams are nearly dry all summer (Fertig et al. 2005, Kendrick 1989). Ute ladies'-tresses has colonized wetlands left behind when peat was mined, and also occurs in drainage ditches alongside roads and railroad tracks (Fertig et al. 2005). In the summer of 2012, the species was rediscovered in Salt Lake County, Utah, after decades of unsuccessful attempts to relocate an historical collection of the species in this county dating from 1953. The county property on which the orchid was recently found has been managed as a flood control basin with permitted horse grazing for the past 50 years. In summary, Ute ladies'-tresses occurs in more than 50 populations distributed across 8 U.S. states and 1 Canadian province; these populations collectively contain some 80,000 individuals. Approximately 80 percent of known populations are associated with lands managed for agriculture or recreation, rivers regulated by dams, or other human-modified habitats (Fertig et al. 2005). Research, monitoring and management activities have demonstrated that ongoing patterns of land use across the range of the species are capable of mimicking or providing the conditions required for the species' persistence.

Recovery

Reclassification Criteria:

Recovery Priority Number: 14C

Recovery Actions:

- Define, manage and restore watersheds
- Implement interim recovery actions for orchid populations associated with natural stream systems
- Identify, protect and manage populations in disjunct habitats
- Develop orchid population and habitat recovery goals and delisting criteria
- Inventory potential remaining habitat
- Conduct genetic, life history, ecology and habitat management studies
- Reintroduce Ute ladies'-tresses into appropriate sites
- Conduct public education on watershed and riparian ecosystem management, use of recovery and interdisciplinary teams, and orchid ecology

References

USFWS 2016. Status of the Species and Critical Habitat: *Spiranthes diluvialis* (Ute ladies' tresses). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

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

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2023. Species status assessment report for Ute ladies'-tresses (*Spiranthes diluvialis*). Version 1, June 2023, Salt Lake City, Utah. 214 pp.

USFWS 2016. Status of the Species and Critical Habitat: *Spiranthes diluvialis* (Ute ladies' tresses). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016. USFWS. 2023. UTE LADIES'-TRESSES (*Spiranthes diluvialis*) 5-Year Status Review: Summary and Evaluation. Mountain-Prairie Region. Denver, Colorado. 26 pp.

USFWS. 2023A. Species status assessment report for Ute ladies'-tresses (*Spiranthes diluvialis*). Version 1, June 2023, Salt Lake City, Utah. 214 pp.

USFWS. 1995. Ute ladies'-tresses (*Spiranthes diluvalis*) recovery plan. U.S. Fish and Wildlife Service, Denver, Colorado. 46 pp.

SPECIES ACCOUNT: *Spiranthes parksii* (Navasota ladies'-tresses)

Species Taxonomic and Listing Information

Listing Status: Endangered; 05/06/1982; Southwest Region (Region 2) (USFWS, 2016)

Physical Description

Spiranthes parksii is an erect, slender stemmed perennial up to 30 cm tall; leaves mostly basal, linear, usually absent when flowering; inflorescence a slender, solitary spike of small flowers surrounded by conspicuously white-tipped bracts; petals rounded or ovate with a green central stripe; lateral petals conspicuously shorter than the sepals; lip margin distinctly ragged (Mahler, 1980). The most unusual characters for identification of *S. parksii* in the field are the short, wide lateral petals, cream colored perianth, and a tendency for the floral bracts, and sometimes the stem bracts to be white-tipped. The small, fragrant flowers bloom from late October-early November. (USFWS, 1984; NatureServe, 2015)

Taxonomy

S. parksii is clearly defined as a taxonomic species, its association with other elements of the genus is not clear at the present time. On the basis of a recent, biosystemic study, there is little doubt that *S. parksii* is clearly within *Spiranthes* s. str., possibly associated with the *S. cernua* complex of species (Sheviak, 1982). (USFWS, 1984)

Historical Range

When Navasota ladies'-tresses was listed in 1982, it was known only from Brazos County. (USFWS, 2009)

Current Range

Texas endemic found in eastern Texas along the Navasota River, primarily in Grimes and Brazos counties. This species has recently been found at Angelina National Forest, in Jasper County, 114 miles east of the nearest population in Madison County. (NatureServe, 2015)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Although genetic evidence (Manhart and Pepper 2006, pp. 38, 50) indicates that rare instances of outcrossing occur, the vast majority of seeds are produced through apomixes (genetic cloning) (USFWS, 2018).

Dependency on Other Individuals or Species

Adult: *Spiranthes parksii* flowers are visited by bumblebees and other insects, but produce polyembryonic seeds even when the flowers have not been pollinated (Catling and McIntosh 1979). The species requires mycorrhizal fungi (Epulorhiza, specifically) for successful reproduction and germination (U.S. Fish and Wildlife Service 2009, Walters 2005, and Wonkka

et al. 2012). (USFWS, 2009)

Breeding Season

Adult: October to November (USFWS, 2009)

Reproduction Narrative

Adult: Charles Sheviak (in. litt. 1986) reported that all polyploid species within the *Spiranthes cernua* complex (including *S. parksii*) are facultatively agamospermic, through adventitious embryony; but the rare occurrence of apparent hybrids between *S. parksii* and *S. cernua* indicate that *parksii* is capable of sexual reproduction. The species requires mycorrhizal fungi (Epulorhiza, specifically) for successful reproduction and germination (U.S. Fish and Wildlife Service 2009, Walters 2005, and Wonkka et al. 2012). *Spiranthes parksii* flowers are visited by bumblebees and other insects, but produce polyembryonic seeds even when the flowers have not been pollinated (Catling and McIntosh 1979). (USFWS, 2009; NatureServe, 2015)

Habitat Type

Adult: Habitats are intact post oak savannas that are influenced by periodic wildfire (USFWS, 2018).

Habitat Vegetation or Surface Water Classification

Adult: Associated with stream banks and drainages in post oak savanna (USFWS, 2018).

Spatial Arrangements of the Population

Adult: Navasota Ladies'-tresses are distributed through habitats in relatively small, scattered colonies, and it is difficult to delineate populations (USFWS, 2018).

Environmental Specificity

Adult: Moderate (USFWS, 2009)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Habitat Narrative

Adult: This terrestrial orchid is found in sandy soil in the post oak savanna of central-east Texas, often along the naturally eroded slopes of the upper reaches of drainages and ephemeral streams, or occasionally near the margins of seeps and swales. Within the post oak savanna, *S. parksii* typically occurs in a specific topographic position where permeable fine sand or sandy loam shallowly overlies less permeable clay. Along these narrow contours of shallow topsoil, where there may be less competition from more robust herbaceous and woody plants, available moisture may be sustained by seepage along the upper surface of the clay stratum. Often in areas where edaphic or hydrologic factors (such as high levels of aluminum in the soil or a perched water table) limit competing vegetation in the herbaceous layer. Besides post oak, associated species include water oak (*Q. nigra*), blackjack oak (*Q. marilandica*), and yaupon (*Ilex vomitoria*). Species does not readily recover from significant disturbance to its habitat or colonize areas with extensive disturbance (Pine 2003). (USFWS, 2009; NatureServe, 2015)

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends**Population Trends:**

Long-term trends are unknown but short-term trends indicate a decline of 10-30% (NatureServe, 2015)

Number of Populations:

64 element occurrences (USFWS, 2009)

Population Size:

~3,000 individuals (USFWS, 2009)

Minimum Viable Population Size:

Estimated to be approximately 1,500 individuals (USFWS, 2018)

Population Narrative:

Long-term population trends are unknown but short-term trends indicate a decline of 10-30%. The total "high count" of 3,651 for all EOs represents the total population size. From this number, 510 individuals have been lost in three large elemental occurrences (EOs), leaving a potential surviving known population of 3,141. The total number of EOs recorded is 64. (USFWS, 2009; NatureServe, 2015). Navasota ladies'-tresses occurs in seven HUC 8-digit units: Navasota HUC8 12070103, Lower Brazos - Little Brazos HUC8 12070101, Lower Trinity-Tehuacana HUC8 12070204, Lower Trinity-Kickapoo HUC8 12030202, Yegua HUC8 12070102, Lower Colorado-Cummins HUC8 12090301, and the Lower Angelina HUC8 12020005 (USFWS, 2018).

Threats and Stressors

Stressor: Habitat loss and modification (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: The primary threats to the continued existence of Navasota ladies'-tresses are habitat loss and modification (Wilson 1993). Approximately 14 percent of the known SPIPAR population has been lost to development of two lignite mines, a landfill, pipelines and highway construction and improvement. An unknown amount of habitat and individuals have undoubtedly been consumed by development projects that did not require Section 7 consultation with USFWS. Diamond and True (2000) documented a loss of 5.8 percent of the forest cover within the post oak savanna region from 1987 to 1997. However, the species is now protected in 24 small reserves, 21 of which resulted from the reasonable and prudent alternatives and measures approved during Section 7 consultation with USFWS. Five of these reserves are owned by TMPA and may be sold after the final release of their bond by the Texas Railroad Commission, scheduled for 2015. Even where the species' habitat remains secure, habitat quality declines as the herbaceous component of the post oak savanna is replaced by a dense woody understory. This "thicketization" has occurred throughout the post oak savanna region, and elsewhere, and is attributed to a greatly reduced frequency of wildfire, and to poor rangeland management

techniques. A team of researchers from TAMU, with support from BVSWMMA, is currently creating an adaptive habitat management plan based on their investigations of *S. parksii* ecology. (USFWS, 2009)

Stressor: Herbivory (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: Deer, squirrels, and perhaps other herbivores cause a significant amount of damage to flower stalks. Hammons et al. (2009) reported that 30 percent of the flower stalks in one trial were browsed by herbivores before they could mature. Although these fauna are native throughout the species' range, white tailed deer are now far more abundant than during pre-settlement times. Introduced feral hogs and native armadillo also cause significant damage to *S. parksii* habitat (Hammons et al. 2009). (USFWS, 2009)

Stressor: Climate change (USFWS, 2009)

Exposure:

Response:

Consequence:

Narrative: According to the Intergovernmental Panel on Climate Change (IPCC) (2007, p. 1) "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years (IPCC 2007, p. 1). It is very likely that over the past 50 years: cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007, p. 1). It is likely that: heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007, p. 1). The Service does not know whether the changes that have already occurred have affected Navasota ladies'-tresses populations or distribution, nor can the Service predict how the species will be affected by the type and degree of climate changes forecast by a range of models. The known populations of Navasota ladies'-tresses are almost entirely restricted to post oak savanna in central east Texas. Rising temperatures might enable the species to survive further north than at present, but might also reduce the southern limit of the range. However, the discontinuous nature of the populations and potential habitat, and the existence of new, anthropogenic barriers to migration, could impede the spontaneous extension of the range. Some climate change models also predict increased precipitation along the Gulf Coast, largely due to increased tropical storm activity and severity (Twilley et. al. 2001). Since the species is an edaphic endemic dependent on ephemeral seeps, increasing or decreasing rainfall could alter its competitive advantage in the unique microhabitats it now inhabits. Regardless of how changes in temperature and rainfall amounts and patterns may affect the autecology of Navasota ladies'-tresses, the altered synecology may be far more significant. The possible effects of climate change on the synecology of Navasota ladies'-tresses habitat are infinitely complex. Therefore, the Service will continue to monitor the species and its habitat, and will adapt our recovery and management strategies when necessary to address the changing conditions. (USFWS, 2009)

Recovery

Reclassification Criteria:

1. One or more viable populations or metapopulations occur in each of the seven HUC 8- digit watersheds within its known range. To be considered viable, each population or metapopulation will consist of at least 1,500 mature individuals, and will total at least 10,500 individual plants across the seven HUCs (USFWS, 2018).
2. The populations or metapopulations that meet criterion 1 occur in protected natural areas. Protected natural areas include lands owned by federal, state, or local government agencies, or by private landowners, that are legally protected for the purpose of conserving native plants and animals and their habitats. Examples include, but are not limited to, state parks, state natural areas, and state wildlife management areas, conservation easements on private lands, lands owned and managed for conservation by non-profit organizations, and legally-binding long-term management agreements with other public agencies or private landowners. To be considered under this criterion, the potential habitats of Navasota ladies'-tresses must be managed in a manner that promotes the continued survival of this species (USFWS, 2018).

Delisting Criteria:

1. The criteria for downlisting to threatened, described above, have been met: One or more populations or metapopulations, each consisting of consisting of 1,500 or more mature individuals, occur in protected natural areas within each of the 7 HUC-8 watersheds of the species' geographic range (USFWS, 2018).
2. Periodic monitoring indicates that the minimum viable population level of 1,500 individuals within each protected natural area remains stable or increases over a period of at least 39 years. Monitoring (censuses) of each protected natural area must be conducted annually for the first 10 years and subsequently every 5 years up to the 39 year timeline (USFWS, 2018).

Recovery Actions:

- Continue monitoring and surveying within the 24 established protected reserves. (USFWS, 2009)
- Conduct surveys of high-potential habitat within the known range of the species, focusing on sites that have not previously been surveyed. (USFWS, 2009)
- Continue to investigate ecology and management, with special emphasis on woody plant control and prescribed burning. (USFWS, 2009)
- Apply sound management, as needed, to protected sites. (USFWS, 2009)
- Seek permanent protection for existing reserves; establish new reserves, using LBJWC conservation fund and other resources. (USFWS, 2009)
- Investigate mycorrhizal symbionts. (USFWS, 2009)
- Obtain peer review and seek consensus on taxonomic status. (USFWS, 2009)
- Collect seeds of representative populations for propagation and seed banking, establish germ-plasm (live plant) refugia, and develop techniques for successful propagation and reintroduction. (USFWS, 2009)
- Establish cooperative efforts to promote the conservation of the post oak savanna ecosystem. (USFWS, 2009)
- Conduct public outreach efforts to encourage conservation of the species and its habitat on private lands. (USFWS, 2009)

References

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

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile.
<http://ecos.fws.gov/ecp/>. Accessed July 2016

USFWS. 1984. Navasota Ladies'-Tresses Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico

USFWS. 2009. Navasota Ladies'-Tresses (*Spiranthes parksii*) 5-Year Review: Summary and Evaluation. Austin Ecological Services Field Office Austin, Texas

NatureServe. 2015. NatureServe Explorer: an encyclopedia of life [web application]. Accessed July 2016

USFWS. 1984. Navasota Ladies'-Tresses Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico

USFWS. 2009. Navasota Ladies'-Tresses (*Spiranthes parksii*) 5-Year Review: Summary and Evaluation. Austin Ecological Services Field Office Austin, Texas.

USFWS. 2018. Recovery Plan for *Spiranthes parksii* (Navasota ladies'-tresses) Draft Amendment 1. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 9 pp.

USFWS. 2009. Navasota Ladies'-Tresses (*Spiranthes parksii*) 5-Year Review: Summary and Evaluation. Austin Ecological Services Field Office, Austin, Texas

SPECIES ACCOUNT: *Trillium persistens* (Persistent trillium)

Species Taxonomic and Listing Information

Listing Status: Endangered; 05/27/1978; Southeast Region (R4) (USFWS, 2017)

Physical Description

A perennial herb, mostly 1-3 dm tall, with a whorl of 3 leaves at the tip of the stem. Each flowering plant produces a single, nodding, 3-petaled pink flower in early spring (mid-March to mid-April) before the surrounding trees leaf out. As with other slow-growing *Trillium* species, it takes 7-10 years to produce a mature, 3-leaved, flowering plant. (NatureServe, 2015)

Taxonomy

The *Trillium* genus is complex and the subject of much phylogenetic research (Weakley 2011). When listed in 1978, the *Trillium* genus was part of the Liliaceae (sensu latu), but Weakley (2011) places the genus within the family Trilliaceae (sensu Dahlgren et al. 1985) in his draft Flora of the Carolinas, Virginia, and Georgia, and Surrounding Areas. Others place the genus within the family Melanthiaceae (sensu Angiosperm Phylogeny Group 1998). No former or future name changes at the specific level are known for *T. persistens*, and changes in taxonomy at the family level do not appreciably change our knowledge of the species, but rather, allows researchers to place *Trillium* within a broader plant evolutionary context (USFWS, 2007).

Historical Range

See current range/distribution

Current Range

Known only from an approximately four square mile area at the head of Tallulah Gorge in Georgia and South Carolina (Flora of North America Editorial Committee 2002) (NatureServe, 2015). Draft current range for *Trillium persistens* sub-populations across the Tallulah River drainage in Georgia and South Carolina. Populations as reported in the recovery plan include the Tallulah River (including Tallulah Gorge, Black Branch and Moody Branch subpopulations), Battle Creek, Moccasin Creek, and Panther Creek (USFWS 1984). (USFWS, 2021)

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Lifespan

Adult: 10+ years (USFWS, 1984)

Breeding Season

Adult: *T. persistens* blooms from mid-March through mid-April and generally matures fruit and sheds seed in July (USFWS, 1984).

Reproduction Narrative

Adult: *T. persistens* blooms from mid-March through mid-April and generally matures fruit and sheds seed in July. If *T. persistens* follows the life-cycle of *T. grandiflora* (Patrick, 1973), then seed shed in July should overwinter and germinate the first spring, producing a primary root, but no stem. The second spring the seed coat is shed and above the cotyledon leaf and petiole is produced. A single, simple leaf is produced each of the third, fourth and fifth springs, and three-leaved plant is produced the sixth spring. If conditions are ideal, a mature flowering-fruiting plant is produced the seventh spring, under less than ideal conditions it may take up to ten years to produce a mature plant (USFWS, 1984).

Habitat Type

Adult: Mixed hemlock-pine-deciduous forests (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: gorges/steep ravines (USFWS, 1984)

Spatial Arrangements of the Population

Adult: Clumped (USFWS, 1984; NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (USFWS, 1984; NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Mixed hemlock-pine-deciduous forests, typically on steep slopes or along streams near rhododendrons (*Rhododendron maximum* or *R. minus*). Occasionally in lowbush blueberry thickets (Flora of North America Editorial Committee 2002; Chafin 2007) (NatureServe, 2015) High ecological integrity and site fidelity as well as Low tolerance ranges are inferred based on limited number of populations and specific habitat needs of the species (NatureServe, 2015)

Dispersal/Migration**Motility/Mobility**

Adult: Low (USFWS, 1984)

Dispersal

Adult: Ants are the apparent agent of seed dispersal (USFWS, 1984)

Dependency on Other Individuals or Species for Dispersal

Adult: Ants (USFWS, 1984)

Dispersal/Migration Narrative

Adult: Ants are apparently the primary agent of seed dispersal (Gates, 1940). Ants collect the seeds and bring them back to their nests. After the elaiosome is eaten, the seeds are carried

outside the nest. Seedlings of Trillium are often seen in close association with ant nest in old, rotten stumps and at the base of trees they also are often seen in groups rather than singly (V.G. Soukup, personal communication, 1982). S. Bowling (personal communication, 1982) has noted in other Trillium species that ants often climb the peduncle, cut off the capsule, open the capsule, and carry off the seeds. Bowling also notes that ants often drop and fail to recover seeds as they carry them to their nests (USFWS, 1984).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Species Trends:

Stable (USFWS, 2021)

Population Growth Rate:

Major dams and reservoirs have inundated former habitat and fragmented the range (Lowe et al. 1990). Decline of 30-50% (NatureServe, 2015)

Number of Populations:

4 (USFWS, 2021)

Population Narrative:

Major dams and reservoirs have inundated former habitat and fragmented the range (Lowe et al. 1990). Decline of 30-50%. In addition, NatureServe notes that there are between 1-20 populations. High counts for the species are around 20,000 plants but this really needs to be updated through survey efforts (USFWS 2011). The Georgia population was estimated to be fewer than 12,000 plants, including juvenile and sterile individuals (Chafin 2007) (NatureServe, 2015). Low resiliency, representation and redundancy are inferred based on low number of populations, small populated area and specific habitat needs of this species (NatureServe, 2015). Populations as reported in the recovery plan include the Tallulah River (including Tallulah Gorge, Black Branch and Moody Branch subpopulations), Battle Creek, Moccasin Creek, and Panther Creek (USFWS 1984). (USFWS, 2021)

Threats and Stressors

Stressor: Logging and Land Clearing (USFWS, 2007)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: The imminence of threats from timber harvest was largely eliminated, first by voluntary conservation efforts on the part of the primary landowner GPC, and then through a transfer of property from GPC to GADNR that created the Tallulah Gorge State Park in 1993. Additionally, GPC transferred ownership of the Panther Creek population to the USFS. The GADNR purchased a privately-owned roadside tourist park (Tallulah Gorge Park) referred to in the recovery plan (USFWS 1984), thus reducing threats of timber removal and development (USFWS, 2007).

Stressor: Recreational use of habitat (USFWS, 2007)

Exposure:

Response:

Consequence: Degradation of habitat

Narrative: Threats to habitat degradation through visitation and usage of trails, roads, and rapids have lessened since the publication of the recovery plan (USFWS 1984). Now maintained as a State park, visitor usage and access to the bottom of Tallulah Gorge is restricted by permit, limiting gorge access to 100 persons per day. Although construction of a wooden stairway (circa 2002) displaced approximately 200 *T. persistens* stems (T. Patrick, pers. comm., 2006), the stairway alleviates foot traffic in natural areas and probably lessened the degree of direct damage to *T. persistens* that would have occurred without the stairway (T. Patrick, pers. comm., 2006, J. Sullivan, pers. comm., 2006). Additionally, GPC made efforts to better control road access to cottages on Lake Yonah land leases within *T. persistens* habitat--no known impacts occurred in this area since 1986 (T. Patrick, pers. comm., 2006). Much of *T. persistens* habitat is extremely steep and/or difficult to access. The Battle Creek population is accessible only by boat, limiting visitation pressure (J. Candler, pers. comm., 2006). A closed campground, below the Wallenda Trail, is recovering, and shrubs and *T. persistens* are moving into areas that were laid bare from foot traffic (T. Patrick, pers. comm., 2006). Excessive visitor usage at the Panther Creek population does not seem to be a threat, as the species is in an area that experiences little foot traffic from trout fishermen or other day-users (J. Sullivan, pers. comm., 2006; C. Wentworth, pers. comm., 2006). (USFWS, 2007).

Stressor: Invasive species (USFWS, 2007)

Exposure:

Response:

Consequence: Loss and/or degradation of habitat

Narrative: Within the last decade the exotic hemlock woolly adelgid invaded Georgia forests. This small, aphid-like insect can heavily infest hemlock (*Tsuga* spp.) trees and cause die-offs of hemlock forest. Hemlock is a component of the canopy at *T. persistens* sites, and the die-off of hemlock from the canopy has the potential to affect the structure and composition of plants in the understory and potentially change the microenvironment and nutrient cycling (Orwig and Foster 1998). Large openings in the forest canopy can also promote the proliferation of weedy and other aggressive plant species that could displace *T. persistens* (USFWS, 2007).

Stressor: Collection (USFWS, 2007)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Collection pressure of the species was identified in the recovery plan (USFWS 1984) as a potential threat. The magnitude of this threat is low, as there will probably always be a few trillium collectors that want all species of Trillium, including *T. persistens*, in their gardens, but these individuals are few (USFWS, 2007).

Stressor: Herbivory/granivory (USFWS, 2007)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: A well-known threat to many rare wildflower species, including trilliums, is herbivory, particularly from white-tailed deer (*Odocoileus virginianus*) (Augustine and deCalesta 2003, Knight 2003, 2004, Miller et al. 1992). Sporadic herbivory by deer is likely to disproportionately affect *T. persistens* growing in gently sloping coves and streambeds, rather than in steep ravines largely inaccessible to deer. Some signs of herbivory were observed at the Moccasin Creek population (J. Candler, pers. comm. 2006), but overall, herbivory does not seem to be a problem at most sites (J. Candler, pers. comm., 2006; J Sullivan, pers. comm., 2006; C. Wentworth, pers. comm., 2006). *T. persistens* habitat is within an area of Georgia with one of the lowest deer populations, approximately 20-30 deer/mi² (GADNR 2005). There are no substantial, new threats to the species from disease or predation. Deer browse is presently not a serious threat to *T. persistens*, as many areas of occupied habitat are steep and generally not conducive to deer browse. However, as urban development of the Georgia mountains continues, and patchy habitats are formed that are conducive to higher production of deer, browse could become more of a concern, especially lower elevation sites on slight grades. Granivory by rodents, especially on the edges of clear-cuts (Jules and Rathcke 1999, Tallmon et al. 2003) and possibly in upslope, xeric areas (Gaddy 1985), may impact the species to some degree, lowering successful seed set and recruitment. However, much of *T. persistens* habitat occurs in large, contiguous blocks of forest. Forest edges that may disproportionately experience increased levels of seed depredation likely account for a small percentage of *T. persistens* global abundance (USFWS, 2007).

Stressor:

Exposure:

Response:

Consequence:

Narrative:

Recovery

Reclassification Criteria:

Protection of essential habitat: It is likely that 75% of the global abundance of the species is within areas that have some level of forest protection. However, the ownership of various land holdings, management needs, abundance of *T. persistens* within each landholding, and levels of species protection need to be reviewed and documented. Although the major partners in *T. persistens* conservation (Georgia Power, Georgia Department of Natural Resources, and the U.S. Forest Service) implemented procedures to keep occurrence areas from being timbered, additional invasive species management needs to be assessed and implemented throughout the species' range before essential habitat for *T. persistens* can be considered protected. This recovery criterion is partially complete (USFWS, 2007).

Determine and implement management guidelines necessary for long-term conservation: More studies are needed to determine population health and demography. Although *T. persistens* occurs in a wide range of conditions, no long-term studies have been implemented to determine population trends or if certain areas and/or management techniques are more conducive to conservation of the species. This criterion has not been met (USFWS, 2007).

Develop a commercial source of plants: This criterion is no longer relevant. Collection pressure is not a contemporary threat to *T. persistens*; therefore, a commercial source of plants is unnecessary (USFWS, 2007).

Enforce laws protecting the species and/or its habitat: This criterion has been met. The appropriate level of enforcement is being applied for the protection of this species (USFWS, 2007).

Develop materials to inform public: This criterion is partially complete. More information could be produced to inform the public about this species and on-going recovery efforts (USFWS, 2007).

Recovery Actions:

- Efforts should be employed to eradicate kudzu presently established at US 441 in the Tallulah Gorge/Tallulah River population and on the floodplain below the Panther Creek population. Threats from kudzu are currently localized, but could become a problem in the next ten years if not adequately controlled. Eradicating kudzu would require at least a few years, but could be done, at present, relatively inexpensively at US 441 and Panther Creek. Inattention to the problem of kudzu eradication now would only increase the financial and biological costs of controlling this aggressive invader in the future. A stand of English ivy at the former, private roadside park (Tallulah Gorge Park) should also be controlled, but probably does not pose as large of a threat to *T. persistens* habitat as kudzu, considering its slower rate of growth (USFWS, 2007).
- Annual monitoring of occupied *T. persistens* habitat should be employed at all populations to evaluate potential threats from the hemlock wooly adelgid and potential infestations by invasive plant species (USFWS, 2007).
- Genetic analyses should be funded to determine variation among and between populations and/or their segments. Detailed genetic analyses represent a primary data need and are imperative to objectively direct management decisions to populations most important for preserving the genetic integrity of the species (USFWS, 2007).
- The effectiveness of recovery criteria and the implementation schedule should be evaluated and the recovery plan updated, as deemed necessary (USFWS, 2007).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS (listed in order of priority) a) Continue efforts to eradicate kudzu presently established at US 441 in the Tallulah Gorge/Tallulah River population and on the floodplain below the Panther Creek population. Threats from kudzu are currently localized, but could become a problem in the next ten years if not adequately controlled. Eradicating kudzu would require at least a few years, but could be done, at present, relatively inexpensively at US 441 and Panther Creek. Inattention to the problem of kudzu eradication now would only increase the financial and biological costs of controlling this aggressive invader in the future. A stand of English ivy at the former, private roadside park (Tallulah Gorge Park) should also be controlled, but probably does not pose as large of a threat to *T. persistens* habitat as kudzu, considering its slower rate of growth. b) Continue monitoring of occupied *T. persistens* habitat should be employed at all populations to evaluate potential threats from the hemlock wooly adelgid and potential infestations by invasive plant species. c) Continue monitoring of areas impacted by escaped wildfire to aid in the development of prescribed fire management plans for the area. These plants will minimize future prescribed fire impacts on the species and habitat, as well as reduce the likelihood of catastrophic wildfire in the surrounding habitat area. d) In partnership with GPCA and agencies, continue to develop and improve a stratified monitoring strategy that facilitates better species status assessment, and population-level dynamics. e) Genetic analyses should be funded to determine

variation among and between populations and/or their segments. Detailed genetic analyses represent a primary data need and are imperative to objectively direct management decisions to populations most important for preserving the genetic integrity of the species. (USFWS, 2021)

- Recovery criterion—Protection of essential habitat • It is likely that 75% of the global abundance of the species is within areas that have some level of forest protection. However, the ownership of various land holdings, management needs, abundance of *T. persistens* within each landholding, and levels of species protection need to be reviewed and documented. Although the major partners in *T. persistens* conservation (Georgia Power, Georgia Department of Natural Resources, and the U.S. Forest Service) implemented procedures to keep occurrence areas from being timbered, additional invasive species management needs to be assessed and implemented throughout the species' range before essential habitat for *T. persistens* can be considered protected. This recovery criterion is partially complete. • Additional searches for new *T. persistens* sites is not warranted, as successive searches over the past decades have not appreciably changed the global range of the species. This recovery action has been completed. • Additional and regular censuses of population size and age-class are needed to determine population trends. Surveys should occur across the species' range and data should be collected during a number of successive years to determine variability. This recovery action has not been completed. • Population protection priorities should focus on performing genetic analyses on inter and intrapopulation variation to determine how much land or abundance of *T. persistens* needs to be in permanent protection. This action has not been met. • Implementation of the most appropriate protection measures for the species has been partially met. Additional invasive species control needs to be implemented at a few sites and long-term management plans that benefit the species need to be drafted and implemented. This action has been partially met. (USFWS, 2021)

References

U.S. Fish and Wildlife Service. 2007. PERSISTENT TRILLIUM (*Trillium persistens*) Duncan 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Georgia Ecological Services Office Athens, Georgia

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

USFWS. 2017. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed March 2017. USFWS. 2021. Persistent Trillium (*Trillium persistens*) Duncan 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South-Atlantic Gulf Region Georgia Ecological Services Office Athens, Georgia. 27 pp.

U.S. Fish and Wildlife Service. 1984. Persistent Trillium Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 69 pp

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2021. Persistent Trillium (*Trillium persistens*) Duncan 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South-Atlantic Gulf Region Georgia Ecological Services Office Athens, Georgia. 27 pp.

U.S. Fish and Wildlife Service. 2007. PERSISTENT TRILLIUM (*Trillium persistens*) Duncan 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Georgia Ecological Services Office Athens, Georgia.

USFWS. 2007. PERSISTENT TRILLIUM (*Trillium persistens*) Duncan 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Georgia Ecological Services Office Athens, Georgia.

USFWS. 2021. Persistent Trillium (*Trillium persistens*) Duncan 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South-Atlantic Gulf Region Georgia Ecological Services Office Athens, Georgia. 27 pp.

SPECIES ACCOUNT: *Trillium reliquum* (Relict trillium)

Species Taxonomic and Listing Information

Listing Status: Endangered; 04/04/1988; Southeast Region (R4) (USFWS, 2016)

Physical Description

A perennial herb with 3 mottled leaves at the top of an S-shaped, somewhat decumbent stem, 7-20 cm long. A sessile, 3-petaled flower appears at the apex of the stem in early spring. The flowers range in color from greenish to brownish-purple and, occasionally, to pure yellow. (NatureServe, 2015)

Taxonomy

Trillium reliquum, an herbaceous member of the lily family, was recognized as a distinct species by Freeman (1975) after his extensive study of this complex, taxonomically difficult group (USFWS, 1990).

Historical Range

Historic distribution of this species is unknown; however, it is reasonable to assume that the currently known populations were originally much larger and that there were additional populations that have been lost to development (USFWS, 1990).

Current Range

Eastern Alabama, Georgia, and South Carolina (NatureServe, 2015).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Breeding Season

Adult: The plant flowers from early March through the beginning of May. The peak flowering period is between late March and early April (NatureServe, 2015)

Reproduction Narrative

Adult: *T. reliquum*, a herbaceous member of the Lily family was not recognized as a distinct species until 1975 by Freeman. The general lifecycle is similar to that of most *Trillium* species and can be described as follows: The flowers appear in early spring and are greenish to brownish purple or occasionally pure yellow in color. The fruit is an oval-shaped, berry-like capsule which matures in early summer. *T. reliquum* is perennial from a tuberous rhizome, and like other members of the genus, it dies back to this rhizome after the fruit matures (Freeman 1975). There is very little information on the reproductive biology of this species. The plant flowers from early March through the beginning of May. The peak flowering period is between late March and early April. In Alabama rove beetles (Staphylinidae) and a number of species of small flies of several families have been seen visiting relict trillium (Folkerts, 1987). In South Carolina seed set has been noted in two colonies. At the Relict Trillium Creek colony (part of the Fox

Creek population) 745 plant out of an estimated 40,000 plants set fruit in 1989 (Rayner, 1989). At the Savannah River Bluffs colony (also part of the Fox Creek population) one plant out of approximately 250 plants set fruit. In 1990 two plants in this colony set fruit (Soblo, 1990). The reddish-brown color and fetid odor are typical of the sapromyophily syndrome in which pollination results from the visits of flies which oviposit in decaying organic material or fungi. The only reward which flower visitors can obtain is pollen, since the flowers produce no nectar. Visitors are most abundant in the flowers during the period of high pollen availability. The fruits of *T. reliquum* are not adapted for long distance dispersal and most likely fall a short distance from the parent plant. They could be washed downslope by water, or carried by small animals (insects), but have only remote chances of extrapopulation dispersal. However, this alone cannot explain its rarity, in that all of its more widespread relatives have virtually identical seed dispersal. The populations of *T. reliquum* vary in both size and density throughout the range. Within the populations, the individuals are scattered seemingly at random over varying areas. Population sizes range from 20 to 100 thousand individuals. Densities range from 50 plants/square meter down to well-spaced individuals 5-10 feet apart in marginal habitat, which is usually marked by extreme steepness, overgrowth by *Lonicera* sp., absence of hardwood canopy, recently disturbed soils, etc. There are also areas within what appears to be excellent habitat where not a single plant of *T. reliquum* can be found. There are 21 known extant populations and one extirpated population. Alabama has four extant populations, Georgia has 14 extant populations and one extirpated population, and South Carolina has three populations (U.S. Dept. of the Interior, 1990) (NatureServe, 2015).

Habitat Type

Adult: Mesic hardwood forests (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: High (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: Moderate (inferred from NatureServe, 2015)

Habitat Narrative

Adult: (Adapted from Freeman 1985.) *T. reliquum* is a species of mesic hardwood forests. The forests can be on slopes of various aspects and inclinations or on bottomlands and floodplains. Soils and subsoils range from rocky clays to alluvial sands: all soils have high organic matter content in the top level, in which the rhizomes grow. Soil samples from five sites in South Carolina show that relict trillium is found where there is a medium (800 ppm.) to high (1900 ppm.) level of calcium in the soil. Botanists in other States have noted that calciphytes are normally found with relict trillium. Magnesium levels are also high (101 ppm.) at the South Carolina sites. Soil pH varies from 4.6 to 5.5 at these same sites. All known populations are relatively close to creeks or rivers where high relative humidity is maintained for most of the year, especially under the hardwood canopy during the late spring and summer seasons. The

largest and most vigorous populations are in the Lower Piedmont/Fall Line Hills Province, in drainages of both the Savannah and Chattahoochee Rivers. Species composition at the various sites is quite different, but the one factor that seems to separate the localities supporting *T. reliquum* from similar nearby ones without it is the absence of evidence of wood fires. The species is not found in any woodland where fires, either recently or in the distant past, appear to have influenced the vegetation. Plants were found in forests where other forms of disturbance were noted (e.g., on several abandoned roadbeds, a road embankment, an abandoned railroad grade fill, near an abandoned quarry, etc.), but surrounding woods (the probable seed source) in each case had been subjected only to cutting of selected trees at various times in the past. *T. reliquum* is associated with many other perennial herbs, shrubs and trees at various localities, but no interdependence among these species other than similar habitat preference is apparent. It occurs sympatrically with other *Trillium* species (commonly *T. maculatum*) at most sites, but it is also the only *Trillium* present at two sites. Population vigor is not correlated with diversity of native species with which it occurs. The number of relict *trillium* plants in an area usually is inversely correlated with the density and vigor of Japanese honeysuckle (*Lonicera japonica*) in the ground cover (NatureServe, 2015). High environmental specificity, ecological integrity, moderate site fidelity and low tolerance range are inferred based on specific habitat needs and moderate number of populations.

Dispersal/Migration

Dispersal

Adult: Unknown. Ants are known dispersal mechanisms, but others are unknown and distance of dispersal is unknown (USFWS, 2014).

Dispersal/Migration Narrative

Adult: Carrion insects, including fly and beetle families, attracted to the fetid smell of the green to maroon sepals, are believed to be the dominant pollinators, while ants are noted as important dispersal mechanisms for the species (Folkerts et al. 1987; Waddell 2006) (USFWS, 2014).

Population Information and Trends

Population Trends:

Not available

Number of Populations:

44 Extant Populations (USFWS, 2023)

Population Size:

1000 - 1,000,000 total individuals (NatureServe, 2015)

Adaptability:

Persistent if site not heavily disturbed, yet limited in its ability to recolonize due to limited seed dispersal. (NatureServe, 2015)

Population Narrative:

Persistent if site not heavily disturbed, yet limited in its ability to recolonize due to limited seed dispersal. Population size is noted as between 1000 and 1,000,000 and number of populations is between 21 and 80 (NatureServe, 2015). Low resiliency and representation are inferred based on specific habitat requirements and inferred poor ability to generate new populations or replace existing populations. Relict trillium is a small perennial herb, native to 24 counties across the lower Piedmont, Fall line and upper Coastal Plain of Alabama, Georgia, and South Carolina. It occupies four HUC-6 basins (Altamaha, Apalachicola, Choctawhatchee, and Savannah). The 2023 SSA delineated six representation units (RUs). Relict trillium's known range has increased, and numbers of occurrences have quadrupled from 21 to 102 over the last 30 years. However, the increase is likely due to continued survey efforts and new finds, rather than an actual expansion of range or populations. The occurrences were grouped into 61 distinct populations, 44 of which are considered current. Of 44 current populations, 50 percent were considered to have high or moderate resiliency. Most of the populations are located at the center of the range. The RUs representing the western and eastern extents of the range are known to have the highest genetic diversity but have the fewest populations. In general, relict trillium has slightly moderate resiliency, moderate redundancy, and reduced representation. Seventeen populations occur, at least partially, on protected lands (one in AL, 15 in GA, and one in SC) (USFWS, 2023).

Threats and Stressors

Stressor: Development, Road construction and timber operations (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: Three populations are known to have been damaged or reduced in size by development, road construction and timber operations since 2004. It is not known how many other populations may have suffered damage because there is no organized effort to monitor populations on private lands. Negotiations were recently (2006) completed between TNC and two timber companies to minimize damage to one Georgia population and one Alabama population that are scheduled to be clear cut. The Pobiddy Road and Potato Creek Element Occurrences represent one population that was impacted by a bridge replacement and road maintenance in 2005 (U.S. Fish and Wildlife Service 2005). Impacts caused by the Georgia Department of Transportation were mitigated by the State of Georgia purchasing these sites for conservation. The Randal Creek North element occurrence was severely impacted by road construction in 2007, with more than 1200 stems and 3 acres of habitat destroyed (U.S. Fish and Wildlife Service 2007). Approximately 1250 rhizomes of relict trillium were rescued from the site by the Georgia Plant Conservation Alliance. Two safe guarding sites were identified, and the plants were divided and established on those sites (USFWS, 2014).

Stressor: Disease and Predation (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of individuals

Narrative: Cutworms are listed as a threat to this species as is deer and feral hog browsing/rooting. Disease has been reported to affect one relict trillium population at Ft. Benning, Georgia. However, the report of disease was later thought to be caused by dry weather (USFWS, 2014).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: State laws and regulations in Alabama, Georgia, and South Carolina do not provide protection for relict trillium habitat on private land (GADNR 2006). Since the Endangered Species Act (ESA) provides very limited protection for listed plants and their habitat on non-Federal land, most populations are at risk from development and other land use changes. At least one population was severely impacted by development on Ft. Benning (U.S. Fish and Wildlife Service 2007). At least one (USFWS 1990) and perhaps more populations have been extirpated by development on private land holdings. The majority of populations in Alabama, Georgia and South Carolina have not been visited by biologists in several years and their current condition is unknown (USFWS, 2014).

Stressor: Invasive plants (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Exotic invasive plants pose threats to trillium populations through competition for space and nutrients. The recovery plan mentioned honeysuckle (*Lonicera* spp.) and kudzu (*Pueraria lobata*). Another plant that is a range-wide concern is privet (*Ligustrum* spp.) Common chickweed (*Stellaria media*) is a concern at one site in Georgia (C. Prior, pers. comm., 2006). These invasive species may be found in relict trillium habitat singly or in various combination and densities, complicating suppression efforts. Honeysuckle can be controlled with applications of the herbicide glyphosate (Heckel and Leege 2004; Thornton 2005) and is especially useful after senescence of relict trillium stems and leaves. Chickweed (*Stellaria* spp.) grows and sets seed during the early spring when relict trillium is actively growing above ground and most susceptible to herbicide, which could make control by herbicide more difficult (USFWS, 2014).

Stressor: Fire (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Fire, whether wildfire or prescribed burning, was recognized in the recovery plan as a threat to relict trillium, based on habitat requirements of hardwood overstory and a thick duff layer. A burn during the spring when relict trillium is actively growing and flowering could be especially harmful, eliminating reproduction and reducing transfer of nutrients to the rhizomes. Fire during other times of the year would reduce or eliminate the duff layer and could destroy trillium seeds. One population on Fort Benning was burned in a wildfire during the spring of 2003, destroying the vegetative parts above ground. Annual monitoring has shown an almost complete recovery by the spring of 2006 indicating that relict trillium populations may recover from infrequent fires when given enough time between fires to rebuild energy stores and for habitat to recover (USFWS, 2014).

Recovery

Reclassification Criteria:

Reclassification is not recommended (USFWS, 2014).

Recovery Priority Number: 8C

Delisting Criteria:

The species will be considered for delisting when there are 12 self-sustaining populations (2 in Alabama, 7 in Georgia, and 3 in South Carolina) that are protected to the degree that the species no longer qualifies for being on the Federal list. Although this is less than the total number of populations currently in existence it is believed that it will provide the number of populations needed to insure the continued existence of the species. It should also be noted that at least 10 of the extant populations contain fewer than 200 individuals each. Upon completion of the biological studies required by the plan the recovery criteria will be reevaluated and changed if necessary (USFWS, 1990).

Recovery Actions:

- Provide interim protection (Tasks 1.1 through 1.4) (USFWS, 1990)
- Study species (Tasks 2.1 through 2.5) (USFWS, 1990).
- Conduct required management activities (Task 2.6) (USFWS, 1990).
- Maintain cultivated plants and store seeds (Task 3) (USFWS, 1990).
- Reestablish populations (Task 2.7) (USFWS, 1990).
- Increase public awareness of species (Tasks 5.1 and 5.2) (USFWS, 1990).
- Enforce laws (Task 4) (USFWS, 1990).
- Assess recovery (Task 6) (USFWS, 1990).
- Develop management agreements to abate threats with potential conservation partners including the State, Department of Defense, National Forest, The Nature Conservancy, and appropriate land trust (USFWS, 2014).
- Acquire data necessary to determine the requirements for a self-sustaining population (e.g., minimum number of plants, habitat quality and quantity, distance of pollen and seed dispersal) (USFWS, 2014).
- Establish and maintain populations at a minimum of two botanical gardens (USFWS, 2014).
- Work with the State of Alabama to protect at least one additional population (USFWS, 2014).
- Work with the State of South Carolina to protect at least two additional populations (USFWS, 2014).
- Reevaluate the number and distribution of protected populations necessary to maintain the genetic variability of populations and lineages on each side of the Chattahoochee River, and if necessary revise recovery criteria accordingly (USFWS, 2014).
- Identify the cutworm that is found in South Carolina populations and determine its long term impact on populations (USFWS, 2014).
- Evaluate the impact of the fungal pathogen *Cibironia trilli* and its long-term impact on populations (USFWS, 2014).
- Monitor a representative sample of populations annually for threats (e.g., urban development, timber harvest and stand conversion, fire, invasive exotic species, herbivore or insect damage, sustainability, disease) (USFWS, 2014).
- Conduct additional field research on the impacts of herbivory and invasive species on relict trillium (USFWS, 2014).

Conservation Measures and Best Management Practices:

- **RECOMMENDED FUTURE ACTIVITIES** A detailed discussion of recovery actions and criteria are presented in the recovery plan (Service 1991). Population #s listed below refer to the population numbering system developed in the SSA Report (Service 2023). Alabama Populations: • Establish and improve landowner relationships o All populations • Surveys needed o Populations #1 and 2 (Lee County) • Invasive species control o Populations #6 (Bullock County); #10, 11, and 12 (Henry County) • Deer herbivory and feral hog management o Populations #10, 11, and 12 (Henry County) Georgia Populations: • Establish and improve landowner relationships o Populations #22 and 23 (Harris County) • Surveys Needed o Populations #25 (Muscogee County); #45 (Jasper County) • Invasive Species Control o Populations #37 (Taylor County); #47 (Jones County); #48 (Bibb County); #58 (Columbia County) • Deer herbivory and feral hog management o Populations #14 and 15 (Clay County); #22 and 23 (Harris County); #32 and 33 (Talbot County); #34 (Upson County); #42 (Lee #46 (Jones County); # (Bleckley County) • Formal protection of populations o Populations #22 and 23 (Harris County); #58 (Columbia County) South Carolina Populations: • Establish and improve landowner relationships o Population #60 (Edgefield County) • Surveys needed o Population #60 (Edgefield County); #61 (Aiken County) • Invasive species and deer herbivory management o Population #61 (Aiken County) • Formal protection of populations o Population #61 (Aiken County) – develop formal MOUs and Deed Restrictions on City of North Augusta properties, similar to that which currently exists for a portion of Riverview Park (USFWS, 2023).

References

U.S. Fish and Wildlife Service. 1990. Relict Trillium Recovery Plan. Atlanta, Georgia. 29 pp

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

U.S. Fish and Wildlife Service. 2014. Relict Trillium (*Trillium reliquum*) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Field Office Athens, GA

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A. USFWS. 2023. Relict Trillium (*Trillium reliquum*) 5-Year Status Review: Summary and Evaluation. Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 15 pp.

Fish and Wildlife Service. 2014. Relict Trillium (*Trillium reliquum*)

5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Georgia Ecological Services Field Office, Athens, GA

USFWS. 2023. Relict Trillium (*Trillium reliquum*) 5-Year Status Review: Summary and Evaluation. Southeast Region. Georgia Ecological Services Field Office. Athens, Georgia. 15 pp.

SPECIES ACCOUNT: *Tuberolabium guamense* (No common name)

Species Taxonomic and Listing Information

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

Physical Description

Tuberolabium guamense (NCN) (*Trachoma guamense* is a synonym), an epiphyte in the orchid family (Orchidaceae). (USFWS, 2015)

Historical Range

Historically, *T. guamense* was reported from the islands of Guam, Rota, Tinian, and Aguiguan (Raulerson and Rinehart 1992, p. 127; CPH 2012f—Online Herbarium Database; GBIF 2012f—Online Database). (USFWS, 2015)

Current Range

Tuberolabium guamense (NCN) (*Trachoma guamense* is a synonym) is known only from the Mariana Islands. (USFWS, 2015). Distribution: Guam, Rota, Tinian, Aguiguan (USFWS, 2020b).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Reproduction Narrative

Adult: Not available.

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Shrublands and Trees (USFWS, 2015)

Habitat Narrative

Adult: *Tuberolabium guamense* is found in dry, moist, and wet shrublands on ridgecrests and steep slopes. (NatureServe, 2015). Species is found also found in trees (USFWS, 2015).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends

Population Trends:

Decreasing (USFWS, 2015)

Number of Populations:

7 (USFWS, 2020b). 13 (USFWS, 2020)

Population Size:

8,770 (USFWS, 2020b). ~26,906 (USFWS, 2020)

Population Narrative:

In summary, populations of *Tuberolabium guamense* are decreasing from their initial abundance observed on Guam, and although new data show a higher number of *T. guamense* individuals than previously thought on Rota, *T. guamense* still occupies very specialized niche habitat in the Sabana region. Currently, *T. guamense* is known from seven occurrences: one occurrence of one individual on Guam and six occurrences on Rota, in the forest ecosystem (Gawel et al. 2013, in litt.; Harrington et al. 2012, in litt.; Zarones et al. 2015c, in litt.). It is possible that a few more individuals are scattered across native forests on Guam. A recent survey on Rota (Zarones et al. 2015c, in litt.) reported finding 239 individuals of *Tuberolabium guamense* along 6 of 18 transects surveyed on the Sabana, with a healthy population structure consisting of seedlings, juveniles, and flowering adults. Zarones et al. (2015c, in litt.) estimate that the actual number of *T. guamense* individuals on the Sabana may be as high as 14,600; however, this appears to assume that *T. guamense* is evenly distributed across the Sabana region. The Service does not concur that this species is evenly or uniformly distributed across the Sabana, consequently we conclude that 14,600 individuals is likely an overestimate. (USFWS, 2015). There are approximately 26,906 *Tuberolabium guamense* individuals in 13 populations on Guam and Rota. (USFWS, 2020)

Threats and Stressors

Stressor: Alien species and fire (NatureServe, 2015)

Exposure:

Response:

Consequence:

Narrative: Major threats include alien species and fire. (NatureServe, 2015)

Stressor: Human activity (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: The islands are small and habitats are rapidly being destroyed by human activity (Raulerson and Rinehart 1992, p. 87). (USFWS, 2015)

Stressor: Habitat loss and destruction from agriculture, urban development, non-native animals and plants, fires, typhoons, and herbivory by slugs (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: The remaining representatives of this species and its habitat are vulnerable to ongoing threats posed by the continued habitat loss and destruction from agriculture, urban development, nonnative animals and plants, fires, typhoons, and herbivory by slugs.

Stressor: Climate change (USFWS, 2015)

Exposure:

Response:

Consequence:

Narrative: The Service anticipates the effects of climate change will further exacerbate many of these threats in the future. (USFWS, 2015)

Recovery

Reclassification Criteria:

Not available.

Delisting Criteria:

Not available.

Recovery Actions:

- Threat and Recovery Potential: Full species with a moderate degree of threat and a high recovery potential. (USFWS, 2020b)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Surveys and inventories—Continue to survey for *T. guamense* in historical locations and potentially suitable habitat that has not been surveyed. • Invasive plant monitoring and control—Control established ecosystem-altering nonnative invasive plant species and those that compete with *T. guamense* or modify their habitat. Develop approaches to controlling *Vitex parviflora* that do not negatively impact *Tuberolabium guamense* resiliency. • Fire monitoring and control—Develop and implement fire prevention management plans. • Establish local protection—Add *Tuberolabium guamense* to the Guam and the CNMI Endangered Species list. Create management plans and enforcement to effectively protect *T. guamense* found with Guam conservation areas. • Captive propagation for genetic storage and reintroduction—Collect seeds and other propagules for storage and propagation efforts for maintenance of genetic stock. Determine whole plant translocation protocols to ensure long-term persistence of translocated individuals. • Ungulate predation or herbivory—Construct ungulate exclosures, or erect strategic fencing, around naturally occurring *T. guamense* populations to protect this species and associated habitat from feral ungulates. Ungulate removal should occur as quickly as possible after exclosures are constructed. • Climate change adaptation strategy—Research suitability of habitat in the future due to the impacts of climate change • Alliance and partnership development—Initiate planning and contribute to implementation of ecosystem-level restoration and management, especially between Guam and the CNMI to benefit this species. • Research life history and habitat associations to better identify information that will help guide recovery, for example: specific micro-habitat conditions, pollinators, reproduction, etc. • Research how edge habitat does or does not affect *T. guamense* survival. • Research the effects of the slug herbivory, if any, on *T. guamense*.(USFWS, 2020)
- Additional Current Management Actions: • Surveys and monitoring— o Joint Region Marianas (JRM) surveyed for ESA-listed species, including *T. guamense*, at the Naval Munitions Site (NMS) and Naval Base Guam Telecommunication Site. Surveys were conducted to document locations and estimate population densities in sites that are proposed for ungulate exclusion and forest restoration as well as gain a better understanding of the species distribution and population sizes (JRM 2019). o DOD

has funded contractors to conduct surveys for listed plants, with focus on *Tuberolabium guamense*, on public lands, including Bolanos Conservation Area, as part of the Recovery and Sustainment Partnership Initiative to increase coordination on conservation management actions between DOD and DOI, as part of a Memorandum of Understanding between DOD and DOI (DOD and DOI 2018). • Captive propagation for genetic storage and reintroduction—The Guam Extinction Prevention Program (GPEPP) has 9 plants in their nursery representing one wild individual from Mount Alifan, and 20 explants in micropropagation representing one individual from University of Guam campus property in Mangilao (GPEPP 2018). • Habitat Protection— o An island-wide Habitat Conservation Plan for Guam, that would provide a collaborative and comprehensive approach to endangered species conservation on non-federal lands, is beginning to be developed (USFWS 2020b), but will take years to be finalized. o A 2020 Memorandum of Understanding between JRM and the USFWS outlined a mutual understanding regarding the intentions and future considerations of a Department of Defense Readiness and Environmental Protection Integration Initiative (REPI) to address conservation of upland vegetation communities (DON and USFWS 2020). o Range Fire Management Plan for Marine Corps Ranges on Guam. A range fire management plan to reduce range/wildfire potential, protect and enhance natural and cultural resources, integrate applicable permit and reporting requirements and implement ecosystem management goals, sustainable training, and objectives already supported on existing Marine Corps installations is being drafted. (USFWS, 2020)

References

USFWS. 2016. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed September 2016

USFWS. 2015. Endangered and Threatened Wildlife and Plants

Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register 80(190): 59424-59497. USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

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

Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register 80(190): 59424-59497.

Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia. Federal Register 80(190): 59424-59497. USFWS. 2020. *Tuberolabium guamense* (no common name). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. 30 pp. USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

U.S. Fish and Wildlife Service. 2015. Endangered Status for 16 Species and Threatened Status for 7 Species in Micronesia

Final Rule. 80 Federal Register 190, October 1, 2015. Pages 59424-59497.

USFWS. 2020b. Recovery outline for 23 Mariana Island Species. Portland, Oregon. 22 pp. + appendices.

USFWS. 2020. *Tuberolabium guamense* (no common name). 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service. Pacific Islands Fish and Wildlife Office Honolulu, Hawaii. 30 pp.

SPECIES ACCOUNT: *Tuctoria mucronata* (Solano grass)

Species Taxonomic and Listing Information

Listing Status: Endangered; 09/29/1978; California/Nevada Region (R8) (USFWS, 2016)

Physical Description

An annual grass that germinates in temporary pools, producing slender leaves that float on the water's surface, and then, when the pools dry out for the summer, producing shoots and flowers (the inflorescence is 1.5-6 cm long). Seed set occurs during the hottest part of June and July, after which the plants die. (NatureServe, 2015)

Taxonomy

Solano grass is in the Orcuttieae tribe of the grass family Poaceae (Reeder 1965). Solano grass was originally described under the name *Orcuttia mucronata*, based on specimens collected "12 miles due south of Dixon, Solano County" (Crampton 1959:108). Reeder (1982) transferred this species to a new genus, *Tuctoria*, resulting in the currently accepted name *Tuctoria mucronata*. Other common names are Crampton's Orcutt grass (Griggs 1977b), mucronate orcuttia (Smith et al. 1980), and Crampton's tuctoria (Skinner and Pavlik 1994) (USFWS, 2005).

Current Range

Endemic to California, known only from Olcott Lake and vicinity.

Critical Habitat Designated

Yes; 8/11/2005.

Legal Description

On August 6, 2003, the U.S. Fish and Wildlife Service (Service) designated critical habitat for *Tuctoria mucronata* (Solano grass) (and other vernal pool species) under the Endangered Species Act of 1973, as amended (Act) (68 FR 46684 - 46867). On August 11, 2005, the Service issued a Final Rule that excluded some lands addressed in the 2003 rule from the final designation for economic reasons (70 FR 46924 - 46999). On February 10, 2006, the Service issued administrative revisions to the Final Rule (71 FR 7118-7316). The critical habitat designation for *Tuctoria mucronata* includes one critical habitat unit (CHU), in California.

Critical Habitat Designation

The critical habitat designation for *Tuctoria mucronata* includes one CHU in Yolo County, California. This species critical habitat encompasses approximately 440 acres (ac) (178 hectares (ha)) (68 FR 46684 - 46867; 70 FR 46924-46999; 71 FR 7118-7316).

Unit 1, Davis Communications Annex and Grasslands Area Unit, Yolo County (440 ac (178 ha)) This unit is an important representative of the geographic distribution of the species (criterion 1) because it represents the northern extent of the species' range, and because it is one of only two areas where *Tuctoria mucronata* is known to occur (CNDDB 2002). It also includes the largest remaining *T. mucronata* occurrence (CNDDB 2002). *Tuctoria mucronata* within the unit grows in Northern Claypan vernal pools on Pescadero soils (CNDDB 2002). This unit is located southeast of the City of Davis and south of the South Fork of Putah Creek. Its western boundary lies along the border between Solano and Yolo Counties. The unit contains land owned by Yolo County and by

the DOD (310 (125 ha)) (68 FR 46684 - 46867).

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 primary constituent elements of critical habitat for *Tuctoria mucronata* (Solano grass) are the habitat components that provide (70 FR 46924-46999; 71 FR 7118-7316):

(i) Topographic features characterized by isolated mound and intermound complex within a matrix of surrounding uplands that result in continuously, or intermittently, flowing surface water in the depressional features including swales connecting the pools described in paragraph (2)(ii) of this section, providing for dispersal and promoting hydroperiods of adequate length in the pools; and

(ii) Depressional features including isolated vernal pools with underlying restrictive soil layers that become inundated during winter rains and that continuously hold water or whose soils are saturated for a period long enough to promote germination, flowering, and seed production of predominantly annual native wetland species and typically exclude both native and nonnative upland plant species in all but the driest years. As these features are inundated on a seasonal basis, they do not promote the development of obligate wetland vegetation habitats typical of permanently flooded emergent wetlands.

Special Management Considerations or Protections

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

Once a vernal pool habitat has been protected from direct filling, it is still necessary to ensure that the habitat is not rendered unsuitable for vernal pool species because of factors such as altered hydrology, contamination, nonnative species invasions, or other incompatible land uses. Many of the factors that cause the decline and localized extirpation of vernal pool species can be avoided. Actions that should be avoided include the following: (1) Actions that increase competition from invasive species as many of the species addressed in this rule are threatened by invasion of nonnative species (CNDDB 2001). (2) Alteration of natural hydrology such as construction of dams or other structures that artificially increase the length of vernal pool inundation or construction of ditches that artificially drain vernal pools. (3) Human degradation of vernal pools such as off-road vehicle use, dumping, and vandalism that threatens many of the species addressed in this rule.

Life History**Food/Nutrient Resources****Breeding Season**

Adult: The germination period for *Tuctoria mucronata* seeds is not known, but is presumed to be in May or June (U.S. Fish and Wildlife Service 1985a). *Tuctoria* seedlings do not produce floating

juvenile leaves (Griggs 1980). This species typically flowers in June and sets seed during July (Holland 1987) (USFWS, 2005).

Reproduction Narrative

Adult: The germination period for *Tuctoria mucronata* seeds is not known, but is presumed to be in May or June (U.S. Fish and Wildlife Service 1985a). *Tuctoria* seedlings do not produce floating juvenile leaves (Griggs 1980). This species typically flowers in June and sets seed during July (Holland 1987). The demography of *Tuctoria mucronata* has not been investigated in detail. Annual estimates or counts at Olcott Lake (Holland 1987, California Natural Diversity Data Base 2005) indicated that population sizes for this species fluctuate dramatically from year to year, as do other members of the Orcuttieae. *Tuctoria mucronata* was not observed at Olcott Lake from 1976 through 1980, then reappeared in 1981 (Holland 1987), indicating that viable seeds can persist in the soil for at least 5 years. Apparently both drought years and years of excessively high rainfall are unfavorable for *T. mucronata*; the largest populations were observed after seasons of 45 to 60 centimeters (17.7 to 23.6 inches) of precipitation (Holland 1987) (USFWS, 2005).

Habitat Type

Adult: Vernal pools (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Vernal pools (Natureserve, 2015)

Spatial Arrangements of the Population

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

Environmental Specificity

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

Tolerance Ranges/Thresholds

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

Site Fidelity

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

Habitat Narrative

Adult: Germinates in warm, turbid, somewhat alkaline vernal pools; these dry out by early summer (NatureServe, 2015). *Tuctoria mucronata* has been found only in the Northern Claypan type of vernal pool (Sawyer and Keeler-Wolf 1995) within annual grassland (California Natural Diversity Data Base 2005). Pools where *T. mucronata* occurs tend to be milky from suspended sediments (Holland 1987). The pools that are occupied in Solano County are more properly described as alkaline playas or intermittent lakes, due to their large surface area (Crampton 1959, U.S. Fish and Wildlife Service 1985a), whereas those at the Yolo County site are “relatively small” (C. Witham in litt. 2000a). Soils underlying known *T. mucronata* sites are saline-alkaline clay or silty clay in the Pescadero series (Crampton 1959, California Natural Diversity Data Base 2003). Known occurrences are at elevations of about 5 to 11 meters (15 to 35 feet) (California Natural Diversity Data Base 2005) (USFWS, 2005). High ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred by this species specific habitat

requirements and its limited number of populations.

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Long-distance dispersal is unlikely (Service 1985), but seed may be carried occasionally by waterfowl (family Anatidae), or by tule elk (*Cervus elaphus nannoides*), or pronghorn (*Antilocapra americana*) in historical times (Griggs 1980) (USFWS, 2009).

Population Information and Trends

Population Trends:

Decreasing (USFWS, 2009)

Population Narrative:

Individual numbers vary greatly from year to year based on precipitation. The latest rare grass surveys at the Yolo Regional Grasslands/Davis Communications Site were conducted in 2008, when approximately 5600 individual plants were counted within six relatively discrete basins onsite (J. Gerlach, Environmental Science Associates, in litt. 2008). In 2007, a year with little precipitation, monitors documented only 45 individual Solano grass plants that germinated but were not expected to produce seed (J. Gerlach, Environmental Science Associates, in litt. 2007). Several thousand individual plants were seen at this site in 2000, and transect counts in 2003 provided a population count of at least 1,400 plants. The distribution of the plants within pools has been found to change annually (ESA 2008; J. Gerlach, in litt. 2007). Because the number of germinated plants varies substantially each year depending on inter-annual climatic conditions, to date monitors have not been able to determine a trend for the occurrence (J. Gerlach in litt. 2008) (USFWS, 2009). Low resiliency, representation and redundancy are inferred based on the limited number of populations and the specific habitat needs of this species.

Threats and Stressors

Stressor: Agriculture (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Agricultural development is listed as a threat to this species (USFWS, 2009)

Stressor: Housing developments (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: The original listing noted that the building of housing developments was a threat to this species (USFWS, 2009).

Stressor: Non-native plants (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat/Extirpation of populations

Narrative: The known occurrences of the Solano grass are currently threatened by destruction or modification of habitat due primarily to invasion of vernal pools by non-native plants and to altered hydrology. Development in the region may reduce the options for re-introducing the species to suitable habitat (USFWS, 2009).

Stressor: Altered hydrology (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat/Extirpation of populations

Narrative: The hydrology at Olcott Lake has likely been altered by bisection of the lake by an elevated gravel road, and by construction of a small drainage ditch. Altered hydrology has been suggested as one potential factor in the extirpation of Solano grass from the site (CNDDDB 2009). Management activities at protected sites have the potential to modify habitat for this species. Volunteers began planting oak trees (*Quercus* spp.) at the Yolo County site about 15 years ago. Some trees were planted close to vernal pools; however, the plantings have been stopped. Managers do not consider the trees to be an issue for the Solano grass because the soils where the grass occurs are not conducive to growing oaks, so oaks seldom survived in that habitat. In addition, a prescribed burn and subsequent wildfires at the property have killed some of the oaks so that the oaks are not proximate to Solano grass occurrences (S. Lines and C. Alford, pers. comm. 2007) (USFWS, 2009).

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: In summary, without protection under the Endangered Species Act, regulatory mechanisms to protect the Solano grass would be inadequate. State regulations also do not protect habitat for the species. Changes in implementation of the Clean Water Act may result in greater losses of vernal pool habitat on private lands as fewer permits are required under section 404. Other Federal regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act (USFWS, 2009).

Stressor: Fragmentation (USFWS, 2009)

Exposure:

Response:

Consequence: Lack of generic variability

Narrative: The continuing fragmentation of Solano grass habitat range-wide may increase the isolation of the few known occurrences of this species. In contrast with some other vernal pool plant species, Solano grass seeds are not likely to be dispersed by waterfowl, as seeds of the *Orcuttieae* tribe do not become viable until mid to late summer when vernal pool areas are dry and waterfowl are unlikely to be present (J. Gerlach, in litt. 2007) (USFWS, 2009).

Stressor: Inbreeding Depression, Genetic Drift, and Stochastic Extinction (USFWS, 2009)

Exposure:

Response:

Consequence: Lack of generic variability

Narrative: The Service does not have any additional information on inbreeding depression or genetic drift within Solano grass populations. The few populations are considered to be isolated from each other, and continue to be threatened by the risk of stochastic extinction due to unforeseen natural and man-caused catastrophic events (e.g., droughts, fires, and accidental destruction of suitable habitat by grading, etc.), that may eliminate one or more occurrences (Goodman 1987; Gilpin and Soulé 1986). In addition, pollination success may be hampered by the small size of extant populations (Davis et al. 2006) (USFWS, 2009).

Stressor: Contaminants (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat/loss of individuals

Narrative: The introduction of pesticides and other contaminants into vernal pool waters may threaten occurrences of the Solano grass. Glyphosate herbicides are being used to control invasive plant species at sites where the Solano grass is present (C. Alford, in litt. 2007); however, the Service has determined that at these sites the herbicides are being applied in a manner that precludes threats to the plant's persistence. Under Service-approved measures, broadcast application of herbicides and pesticides is restricted to areas that are a minimum of 250 feet from the outside edge of any vernal pool or swale habitat that may support federally listed species. Within the habitats of federally protected species, including the Solano grass, application of herbicides and pesticides is limited to hand application (such as painting/wick methods) that is completed only during the dry season when there is no standing water in the application areas (Service 2007) (USFWS, 2009).

Stressor: Drought and Climate Change (USFWS, 2009)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Drought is likely to decrease or terminate reproductive output as pools fail to flood, or dry up before reproduction is complete. In a Mediterranean climate such as that of California, the annual season of precipitation (November to March) is relatively predictable, although the amount of precipitation can vary substantially from year to year (Graham 2003). For population maintenance, vernal pools must last longer, on average, than the time needed for a species to reach maturity and produce viable seeds, and relatively small changes in the timing or amount of precipitation can affect population dynamics (Graham 2003). Climate change has the potential to adversely affect the Solano grass through changes in vernal pool inundation patterns and temperature regimes. Vernal pools in California's Central Valley are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality (Field et al. 1999). Climate change is expected to lead to increased variability in precipitation (McLaughlin et al. 2002), and to increased loss of soil moisture due to evaporation and transpiration of water from plants (Field et al. 1999), which may exacerbate effects due to drought. Although the specific effects of climate change on the Solano grass are unknown, the effect of warming temperatures on winter storm events and pool conditions have the potential to adversely affect this species. Germination of the Solano grass is known to vary dramatically with inter-annual variation in climatic conditions (Holland 1987). Such interannual population fluctuations may be amplified by changes in precipitation and lead to rapid extinctions of individual populations (McLaughlin et al. 2002) (USFWS, 2009).

Recovery**Delisting Criteria:**

The Recovery Plan discusses a variety of participation programs to achieve the goal of recovery of the listed species in the plan. An essential component of this collaborative approach is the formation of a single recovery implementation team overseeing the formation and function of multiple working groups formed at the vernal pool region level. The Service is currently in the preliminary stages of organizing both a recovery implementation team and multiple working groups. Service employees have met with various stakeholders to determine interest of stakeholders to be involved in working groups and/or the recovery implementation team. This criterion has not yet been met (USFWS, 2009).

Recovery Actions:

- 1. Recovery: Re-introduce Solano grass to Olcott Lake at the Jepson Prairie Preserve. Introduce the plant to other suitable vernal pools in a buffer around Jepson Prairie, potentially including East Wilcox Ranch and the Tule Ranch area in the Yolo Bypass Wildlife Area. Pursue placing the unprotected Solano Grass occurrence on private land under a conservation easement. Work with the Rancho Santa Ana herbarium to preserve the accessioned Solano grass seeds for potential use in restoration efforts (USFWS, 2009).
- 2. Research: Fund continuing research for the Solano grass that assesses the pollination ecology for the species, barriers to pollination, determines long-term trends in population growth, and experimentally measures probabilities of local extinction and recolonization (USFWS, 2009).
- 3. Monitoring: Develop and implement a standardized formal monitoring program that collects data in sufficient detail to evaluate species status and examine changes in population dynamics and community composition (USFWS, 2009).
- 4. Habitat Management. Develop management indicators for identifying potential problems and assessing ecosystem health as it pertains to the Solano grass. Establish requirements for appropriate management of vernal pool landscapes. Establish improved guidelines, monitoring protocols, and success criteria for appropriate management of this species (USFWS, 2009).

References

U.S. Fish and Wildlife Service. 2005. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Portland, Oregon. xxvi + 606 pages

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

U.S. Fish and Wildlife Service. 2005. Endangered and Threatened Wildlife and Plants

Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon

Evaluation of Economic Exclusions From August 2003 Final Designation. Final Rule. 70 FR 46924-46999 (August 11, 2005)

U.S. Fish and Wildlife Service. 2006. Endangered and Threatened Wildlife and Plants: Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants

Final Rule. 71 FR 7118-7316 (February 10, 2006)

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants

Final Rule. 68 FR 46684 - 46867 (August 6, 2003).

U.S. Fish and Wildlife Service. 2009. Solano Grass (*Orcuttia mucronata* = *Tuctoria mucronata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California

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

U.S. Fish and Wildlife Service. 2009. Solano Grass (*Orcuttia mucronata* = *Tuctoria mucronata*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office Sacramento, California.

SPECIES ACCOUNT: *Xyris tennesseensis* (Tennessee yellow-eyed grass)

Species Taxonomic and Listing Information

Listing Status: Endangered; 07/26/1991; Southeast Region (R4) (USFWS, 2017)

Physical Description

A perennial herb with basal, mostly erect linear leaves, 1-4.5 dm long, and branched flowering stems, mostly 3-7 dm tall, arising from a bulbous base. The inflorescence consists of brown, cone-like spikes, which occur singly at the tips of the flowering stalks and contain small, pale yellow flowers, which open in late morning and close by mid-afternoon (only 1 or 2 flowers are evident at any 1 time). Flowering occurs from August through September. (NatureServe, 2015)

Historical Range

See current range/distribution.

Current Range

The known current and historic distribution of *Xyris tennesseensis* is restricted to the states of Alabama, Georgia, and Tennessee almost exclusively within the Interior Plateau and Ridge and Valley ecoregions (USFWS, 2014).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Food/Nutrient Narrative

Adult: No information available.

Reproductive Strategy

Adult: Sexual (inferred from USFWS, 2014)

Lifespan

Adult: perennial (NatureServe, 2015)

Breeding Season

Adult: Flowering occurs from August through September (NatureServe, 2015).

Key Resources Needed for Breeding

Adult: Open moist sites (USFWS, 2014)

Reproduction Narrative

Adult: Flowers are yellow, bisexual, opening in the late morning. closing by mid-afternoon [only 1 or 2 flowers evident at any one time]; with obovate petal blades 4.5 mm long by 3 mm broad, long-clawed petal bases, and rounded- lacerate apices, borne in a compact, broadly ovoid, terminal, cone- or head-like spike, each flower subtended by one of a series of spirally-arranged,

tough, woody scales (or bracts) which hide the buds and fruits; the bracts are suborbicular, tan or brown with a greenish dorsal area. Fruit an obovoid or broadly elliptical capsule. Seeds ellipsoid, mealy-surfaced, with 18-20 fine longitudinal lines, these sometimes interconnected, about 0.6 mm in length. Flowering occurs from August through September (NatureServe, 2015). Current research on *X. tennesseensis* indicates that flower production and (perhaps) seedling recruitment are most extensive in locations that are relatively sunny and lack an overstory of shrub or tree canopies. The species does best in relatively open moist sites (USFWS, 2014).

Habitat Type

Egg: Although *Xyris* species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Larvae: Although *Xyris* species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Juvenile: Although *Xyris* species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Adult: Wetland (USFWS, 2014)

Habitat Vegetation or Surface Water Classification

Egg: Although *Xyris* species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Larvae: Although *Xyris* species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Juvenile: Although *Xyris* species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Adult: Streams/springs (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Egg: Although Xyris species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Larvae: Although Xyris species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Juvenile: Although Xyris species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Adult: Disturbance (USFWS, 2014)

Geographic or Habitat Restraints or Barriers

Adult: Successive habitats (USFWS, 2014)

Spatial Arrangements of the Population

Adult: Clumped (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (USFWS, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Egg: Although Xyris species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Larvae: Although Xyris species are usually found on acidic soils, *X. tennesseensis* is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-

slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Juvenile: Although Xyris species are usually found on acidic soils, X. tennesseensis is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990). (NatureServe, 2015)

Adult: Although Xyris species are usually found on acidic soils, X. tennesseensis is restricted to basic or circumneutral soils that thinly cover calcareous substrates with year-round seepage or mineral-rich water flow. This species is found in open or thin canopy woods in gravelly seep-slopes or gravelly bars and banks of small streams, springs and ditches (Kral 1990) (NatureServe, 2015). Clumped spatial arrangement, high ecological integrity and site fidelity and low tolerance ranges are inferred based on specific habitat needs of this species and the small number of known populations. It is obligate wetland plant that prefers relatively high pH seeps and streambanks. It has been shown to be a poor competitor and quickly succumbs to ecological succession without periodic disturbance (USFWS, 2014).

Dispersal/Migration

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Species Trends:

Stable (USFWS, 2014)

Population Growth Rate:

At least four sites have been extirpated in the past. Decline of 50-70% (NatureServe, 2015)

Number of Populations:

23 (USFWS, 2014)

Population Narrative:

At least four sites have been extirpated in the past. Decline of 50-70%. There are between 6 and 20 known populations (NatureServe, 2015). Low resiliency, representation and redundancy are inferred based on low number of populations and specific habitat needs of this species (NatureServe, 2015). A more thorough survey completed in 2010 after two years of adequate rainfall indicates plants are still extant in original locations and in former abundances. Currently, a total of 23 populations are known to be extant including three in Bibb County, four in Calhoun County, and one each in Shelby and Franklin Counties, Alabama; four in Bartow County, one in Floyd County, and one in Whitfield County, Georgia; and seven in Lewis County, Tennessee (USFWS, 2014).

Threats and Stressors

Stressor: Habitat destruction (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: This species continues to be threatened by habitat destruction including stream impoundment, habitat conversion for agriculture and residential development, and poor management practices of the few wild populations (Johnson et al 2012) (USFWS, 2014).

Stressor: Competition (USFWS, 2014)

Exposure:

Response:

Consequence: Loss of habitat

Narrative: Competition from woody plant encroachment including overcrowding and overshadowing are factors affecting the specialized habitat requirements of this species. Also, because this species relies on well-lit moist soils to become established, it is vulnerable to diversions of seep or ground water. A decline in number of three populations in Georgia and Alabama was attributed to alteration of disturbance regimes, competition with other plants at each site and recent devastating droughts (Boyd and Moffett 2010) (USFWS, 2014).

Stressor: Inadequacy of regulatory mechanisms (USFWS, 2014)

Exposure:

Response:

Consequence:

Narrative: There are no State laws in Alabama protecting the Tennessee yellow-eyed grass and its habitat. State protections are in place for the species in Tennessee and Georgia but do not provide for the protection against habitat destruction. Tennessee legislation prohibits taking of the plant without the permission of the landowner and regulates commercial sale and export. In Georgia, listed plants or those proposed for listing are protected by the Wildflower Preservation Act of 1973. This legislation prohibits taking of plants from public lands without a permit and regulates the sale and transport of plants within the State. Neither of these statutes provides protection against habitat destruction, which is the principal threat (USFWS, 2014).

Recovery

Reclassification Criteria:

Not available

Delisting Criteria:

Xyris tennesseensis will be considered for delisting when there are 15 adequately protected and managed, self-sustaining populations of the species distributed throughout the historical range and maintained for 10 years. A population will be considered adequately protected when it is legally protected and actively managed. A population will be considered "self-sustaining" if monitoring data support the conclusion that it is reproducing successfully and maintaining stable numbers or increasing (USFWS, 1994).

Recovery Actions:

- Protect and manage populations (USFWS, 1994).
- Search for new populations (USFWS, 1994).

- Investigate potential management techniques (USFWS, 1994).
- Conduct research on species' ecological requirements and life history (USFWS, 1994).
- Maintain plants and seed ex situ (USFWS, 1994).
- Provide public education (USFWS, 1994).
- Initiate periodic monitoring on sites with robust occurrences of the species (USFWS, 2014).
- Attempt to locate additional populations (USFWS, 2014).
- Work to obtain protection for sites on privately owned- lands (USFWS, 2014)
- Actively manage on occupied sites to include woody plant competition control at staggered intervals (USFWS, 2014).
- Explore well-guided safeguarding opportunities for the species on protected public lands (USFWS, 2014).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS ☐ Initiate annual monitoring on sites with robust occurrences of the species to assess population trends, specifically in relation to habitat degradation. ☐ Initiate monitoring on sites with less robust occurrences and prioritize efforts to manage sites, due to the higher risk of extirpation. ☐ Conduct surveys to locate additional populations on seep-slopes, in springy meadows, and on the banks of small streams. ☐ Work to obtain protection for sites on privately-owned lands. ☐ Actively manage occupied sites to include woody plant competition control at staggered intervals. ☐ Investigate and identify potential sites for well-guided safeguarding opportunities for the species on protected public lands. ☐ Conduct more genetic research to determine if out-planting is advised or if there are specific sites that have weighted conservation priority. (USFWS, 2021)

References

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

USFWS. 2014. Tennessee yellow-eyed grass (*Xyris tennesseensis* Kral) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region. Alabama Ecological Services Field Office Daphne, Alabama

USFWS. 2017. Environmental Conservation Online System (ECOS) – Species Profile. <http://ecos.fws.gov/ecp0/>. Accessed March 2017.

USFWS. 2014. Tennessee yellow-eyed grass (*Xyris tennesseensis* Kral) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region. Alabama Ecological Services Field Office Daphne, Alabama.

USFWS. 2014. Tennessee yellow-eyed grass (*Xyris tennesseensis* Kral) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region. Alabama Ecological Services Field Office Daphne, Alabama.

U.S. Fish and Wildlife Service. 1994. Recovery Plan for Tennessee yellow-eyed grass (*Xyris tennesseensis* Kral). Jackson, Mississippi. 24 pp.

USFWS. 2021. Tennessee yellow-eyed grass (*Xyris tennesseensis*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Alabama Ecological Services Field Office Daphne, Alabama. 20 pp.