SPECIES ACCOUNT: *Cladonia perforata* (Florida perforate cladonia)

Species Taxonomic and Listing Information

Listing Status: Endangered; 5/27/1993; Southeast Region (R4)

Physical Description

Cladonia perforata is easily recognized in the field by the conspicuous holes or perforations below each dichotomous branch point and its wide, smooth, yellowish gray-green branches. Unlike other fruticose lichens whose branches develop from the primary or vegetative body, the branches of members of Cladonia and Cladina are developmentally derived from spore-producing structures called apothecia, present as colored, expanded tips of fertile branches. These specialized, hollow branches are called podetia and are structurally characteristic of this group. Cladonia perforata differs from other fruticose terrestrial Cladoniaceae in several podetial characters, including color, shape and texture, in addition to having specific habitat requirements. Cladonia perforata has rather wide (up to 6 mm), pale yellowish gray-green podetia, punctuated in the axils by 1 to 1.5 mm perforations. The branching pattern is complex and consists of roughly subequal dichotomies near the tips and, more commonly, sympodia (unequal branchings with the smaller branch deflected to one side) below (Evans 1952), resulting in a more-or-less compressed tuft. Its outer surface is mostly uniformly smooth. Individual podetia are typically 4 to 6 cm long (Evans 1952), although specimens of up to 8 cm across and several cm high have been observed (R. Yahr, Archbold Biological Station, personal communication 1995). No primary thallus is known. The oldest parts of the podetia degenerate, leaving no means of determining ages. No studies of growth rates in C. perforata have been completed. In boreal areas, growth studies of Cladonia species suggest that one branching occurs each year (Thomson 1967); however, in more tropical areas, more than one branching per year may be possible. Cladonia perforata is suspected to reproduce only by vegetative fragmentation; no spore-producing organs (apothecia) have been described (Thomson 1967). (USFWS, 1999)

Taxonomy

The Cladoniaceae is represented in Florida by the two large, widespread, and closely related genera Cladonia and Cladina. Moore (1968) considers this conspicuous and diverse group to be one of the most important in the Florida lichen flora, represented by a total of 33 species, three of which are endemic to the state. George Llano first collected C. perforata Evans in 1945 from Santa Rosa Island, Florida, and in 1952, Alexander Evans described the species from this type (Buckley and Hendrickson 1988). Both Llano's and Evans' collections of C. perforata were purportedly from Escambia County, but Wilhelm and Burkhalter (1990) determined the actual locality to be in Okaloosa County. No other names have been applied to the species. (USFWS, 1999)

Historical Range

Endemic to Florida (USFWS, 2007)

Current Range

This species is found in the Florida counties of Highlands, Okaloosa, Martin, Palm Beach, Polk, and Manatee (USFWS, 2007)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Food Source

Adult: sunlight

Food/Nutrient Narrative

Adult: Lichens are organisms made up of algae and fungus; together they have a symbiotic relationship. The fungus provides the structure for the organism, and the algae acquires energy for the lichen. The species growth rate and seasonality are unknown (Yahr 1997), but it appears to grow slowly and branches once a year (Yahr 2003, Yahr and DePriest 2005).

Reproductive Strategy

Adult: asexual (fragmentation)

Reproduction Narrative

Adult: The main form of reproduction is presumably through vegetative reproduction (fragmentation), which can happen via tramping or natural breakage after decades of growth in situ (Yahr 2003). No primary thallus (body), apothecia (reproductive structures), and spermagonia (cavity or receptacle in which spermatia are produced) of this species are known (Evans 1952, Moore 1968, Hammer 2000, Yahr 2000a, Cox 2003). Yahr (2003) indicated that this lichen consists of strictly asexual, branching structures, which reproduce via vegetative fragmentation and that genetic studies have so far supported an asexual life history. However, in 2006, specimens collected from the Manatee County site by Anne Cox and Ann Johnson may have been the first documented presence of reproductive bodies recorded for this species.

Habitat Type

Adult: white sand scrubs

Geographic or Habitat Restraints or Barriers

Adult: impeded by dense leaf litter and stems

Spatial Arrangements of the Population

Adult: clumped

Environmental Specificity

Adult: specialist

Tolerance Ranges/Thresholds

Adult: unknown

Site Fidelity

Adult: high

Habitat Narrative

Adult: Endemic to Florida, Florida perforate cladonia is found in sandy soils and white sand scrubs (Evans 1952, Moore 1968) and is highly specific in habitat requirements (Buckley and Hendrickson 1988). Yahr (2000a) suggested that dispersal of this species beyond occupied rosemary scrub patches may be physically impeded by dense accumulations of leaf litter or plant stems in adjacent habitat types. It is patchily distributed in open gaps in rosemary scrub with a fire-prone landscape, co-occuring with other fire-adapted species (Yahr 2000). Fires in peninsular Florida and hurricanes along the Gulf Coast are natural periodic disturbances that may be important in maintaining adequate habitat structure for Florida perforate cladonia (Menges and Kohfeldt 1995; Hawkes and Menges 1996; Yahr 2000). (USFWS, 2007)

Dispersal/Migration

Motility/Mobility

Adult: mobile

Dispersal

Adult: very limited

Dispersal/Migration Narrative

Adult: Yahr and DePriest (2005) state that an important part of the lichen demography is estimating dispersal of various propagules including spores, vegetative fragments, or specialized structures. Although some lichens can colonize disjunct habitat patches via spores or specialized long-distance dispersal units, Florida perforate cladonia has only large, bulky, vegetative fragments, which are poor dispersers (Yahr and DePriest 2005). Limited dispersal may be the most important demographic feature of this species (Yahr 2000, Yahr and DePriest 2005). Unoccupied but otherwise suitable sites can support lichen; survival of transplants into recently burned or unoccupied suitable sites is nearly 100 percent (Yahr 2000, Yahr and DePriest 2005). (USFWS, 2007)

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

unknown

Number of Populations:

35 (USFWS, 2021)

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

low

Population Narrative:

Limited detailed information is available on abundance and trends. Florida perforate cladonia does not have an established monitoring program at most sites. Using data from FNAI (2006) and DOF (2006), there appear to be 29 element occurrences, which have been grouped into 16 populations (DOF 2006, FNAI 2006, Turner et al. 2006) based upon the assumption that populations are greater than 3280 feet. This population approach of merging element occurrences within 3280 feet buffers probably represents the biological structure of diversity of this lichen in terms of dispersal and connectedness at this time. The 16 populations occur in 4 separate geographic areas. Abundance data for most populations is generally lacking or outdated. In a comprehensive study, Hilsenbeck and Muller (1991) conducted field surveys of 12 known occurrences in Highlands and Okaloosa Counties. At that time, results suggested that there were, at a minimum, over 26000 individuals wtihin 11 extant populations. Hilsenbeck and Muller (1991) indicated that their estimates were rough due to the difficulty in physically counting such a small and relatively inconspicious organism. They believed that they had grossly underestimated the true number of individuals because they accounted for only larger and more readily apparent individuals within a given site rather than small lichen fragments. Florida perforate cladonia is a narrow endemic, distributed in widely disjunct regions and restricted to isolated patches of suitable habitat (Yahr 2000b). There are currently 35 extant populations within 4 distinct metapopulations (Table 1). Of these 35 populations, 13 were discovered since the previous status review (Service 2007), which increased the known ranges of the Lake Wales Ridge and Atlantic Coastal Ridge metapopulations (Richardson and Moore 2009, 2011; Herring 2021; Ward 2021). However, only 14 of the 35 extant populations are known (8) or estimated (6) to be stable or increasing, and 21 are declining or have unknown status (Table 1). Although regular abundance data has been collected at some populations (10), information on natural recruitment and size class distribution needed to determine status trends is lacking for all populations. Since the previous status review (Service 2007), 1 population and 7 sub-populations have become extirpated, and 1 new population and 1 sub-population were introduced (Richardson and Moore 2011; DeBolt 2021; Herring 2021; Ward 2021). Despite recovery efforts and the increased number of populations, only a few of the Florida perforate cladonia populations are large enough to withstand stochastic events (Service 2019), and even large populations and sub-populations have become extirpated or nearly extirpated due to hurricanes and fires (Eglin 2006; Rosner-Katz 2021; Ward 2021). (USFWS, 2021)

Threats and Stressors

Stressor: Habitat destruction or modification (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Florida perforate cladonia continues to be threatened by habitat loss, modification, and fragmentation. Sources of habitat impacts have been characterized as follows: agriculture (i.e., crops, agroindustry fanning, large-scale agriculture, non-timber plantations); land management of nonagricultural areas (i.e., abandonment and change of management regime);

infrastructure development (i.e., human settlement, fires) (Yahr 2003). Although many sites are protected, habitat loss along the Lake Wales Ridge and Atlantic Coast Ridge remains a significant threat (Yahr 2003). In these areas, private lands that support unprotected subpopulations or habitat are at risk of development due to high real estate values, and long-term persistence of these occurrences are unlikely without protection (Yahr 2003). Similarly, occupied and suitable habitat in. Manatee County that is on private, unprotected land is at risk of habitat loss and degradation due to development and agriculture. Scrub habitats are becoming increasingly fragmented and isolated by urban and agricultural development; recovery of small, isolated populations following a natural disturbance may be more unlikely since larger breaks in suitable habitat exist, making recolonization through natural 15 dispersal more difficult or impossible (Yahr 1997). (USFWS, 2007)

Stressor: Improper fire and land management (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Fire is a critical component in the conservation of this species, and improper fire management is considered a threat throughout its range (Yahr 2003). Although some sites have active fire management programs (e.g., Archbold, Lake Wales Ridge State Forest), use of fire at other protected sites is less certain; lack of fire at unprotected sites is also a concern. Yahr (pers. comm 2007) suggests the loss of even a small percentage of subpopulations could be a problem for this species, since it has few refuges from development, climate change, and habitat loss from management decisions (i.e., too frequent or too infrequent fire return intervals). (USFWS, 2007)

Stressor: Disease or predation (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: The final listing rule did not identify disease or predation as threats (58 FR 25746). However, in 2004, Florida perforate cladonia being housed at HBS appears to have been impacted by a pathogen or mold (Eglin 2004b). Three of four hurricanes that made landfall in 2004 impacted HBS, and prior to each stolin HBS personnel collected thalli from the garden bed, placed them in a bucket with native sand, and brought these indoors for protection (Eglin 2004b). After each storm passed, thalli were returned to the garden bed (Eglin 2004b). Although lichen appeared unaffected following the first hurricane, overall health appeared to decline after the last two storms (Eglin 2004b). Yahr suggested that this could he due to loss of native sand during the storm event and / or the result of not fully drying out while indoors, causing them to be affected by some pathogen or mold (Eglin 2004b). The original thalli relocated to FIBS have died with one cause being pathogen or mold (D. Teague, pers. comm. 2007). Eglin is awaiting a new permit to take additional lichen to HBS with precautions in place for future relocations (D. Teague, pers. comm. 2007). Precautions are now in place should the lichen need to be moved indoors in the future (Eglin 2004b). In addition, precautions to prevent growth of mold have been incorporated into Eglin's reintroduction protocol (Eglin 2005b). At this time, it is difficult to assess the overall magnitude and immediacy of this threat. It appears that precautions are in place to reduce this threat in controlled environments. The extent to which pathogens or mold occurs on Florida perforate cladonia in its natural habitat is not known. (USFWS, 2007)

Stressor: Inadequacy of existing regulatory mechanisms (USFWS, 2007)

Exposure:
Response:
Consequence:
Narrative: At the time of Federal listing, Florida perforate cladonia became a State endangered species. The Preservation of Native Flora of Florida law, Rule Chapter 5B-40 of the Florida Administrative Code under authority from the Florida Statutes Chapter 581.185, 581.186 and 581.187 (fines defined in 581.141) provides protective measures to the Regulated Plant Index of endangered, threatened, and commercially exploited taxa. Permitting is administered by the Division of Plant Industry of the Florida Department of Agriculture and Consumer Services. It is unlawful for any person to willfully destroy or harvest Florida perforate cladonia growing on the private land of another or on any public land without first obtaining the written permission of the landowner or legal representative of the landowner and a permit from the Division of Plant Industry. With additional State protection, regulatory mechanisms for this species have, in general, improved since its federal listing in 1993. However, despite this added protection, losses of the species and its habitat on public and private land continue to occur. While the taking, transport, and sale of this species is regulated under State law, neither State nor Federqlw provides adequate habitat protection because both laws only protect against possession of the plant and not its habitat. Therefore, existing regulatory mechanisms do not appear to be adequate. (USFWS, 2007)

Stressor: Human activities (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Human activities, including off-road vehicle (ORV) use, trash dumping, and inadvertent trampling during outdoor recreation activities, as identified at the time of listing (58 FR 25746), continue to threaten this species. Physical destruction of the lichen itself and destabilization of its habitat is a concern at some sites. Crushing or trampling by vehicles, animals, and humans may break up thalli into small fragments that are easily carried away by the wind into unsuitable habitats (swages, areas of heavy leaf litter, or other vegetation), easily covered by wind-swept sand, or too small to recolonize suitable habitats. Based upon data from FNAI (2006), it appears that at least 6 occurrences may be impacted by human activities and / or ORV use at three locations (Eglin, Avon Park Lakes, and Jupiter Ridge Natural Area). However, unrestricted human activities have the potential to impact the species or its habitat at any occupied site (public or private). In the North Gulf Coast, recreational use continues to increase on the eastern section of Santa Rosa Island; however, Eglin is taking steps to minimize impacts to Florida perforate cladonia (e.g., exclusion areas, beach access points, designated foot trails, fencing) on the public use portion of the island (Eglin 2005b). Eglin is also taking precautions to protect the lichen (fencing, flagging, monitoring) during mission activities and in restricted areas (Eglin 2005b). However, vehicle damage at the east population has occurred over the years (R. Yahr, pers. comm. 2007). In 2003, damage occurred to lichen within three reintroduced subpopulations when contractors working on fence installation drove ATVs through the area (Stevens 2003). Other documented unauthorized recreation in the restricted area includes: beach driving, sand dune sledding/boarding, night camping, campfires, climbing on and traversing the dunes where not protected. Such activities can result in the physical destruction of the lichen and destabilization of the sand dunes. Management of Florida perforate cladonia should include protection of all sites from vehicle or heavy foot traffic. (USFWS, 2007)

Stressor: Natural events (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Natural events such as storms and wildfires are a threat to Florida perforate cladonia and its habitat. However, such natural periodic disturbances may be important in maintaining adequate habitat structure (Menges and Kohfeldt 1995, Hawkes and Menges 1996, Yahr 20004- Florida perforate cladonia has no apparent recovery mechanism (e.g., stored seed, spore bank, persistence of underground penetrating structures) for tolerating disturbances and can survive only in relatively undisturbed areas (Yahr 2000c). With high intensity fires typical of rosemary scrub habitats, this species is extremely susceptible to destruction by fire even in gaps with relatively low fuels (Yahr 2000a). During a prescribed fire at Lake Wales Ridge State Forest in 2005, one large area of lichen (4.4 acres [1.8 ha]) was nearly extirpated because the fire burned hotter than expected despite efforts to ensure survival of the subpopulation (K. Clanton, pers. comm. 2007). Low-fuel patches that do not carry fire are critical refugi.a for this species and must be maintained for subpopulations to persist (Yahr 2000a, 2003). Similarly, hurricanes are a major threat, causing overwash and windthrow into unsuitable habitat (Yahr 2003). Unattached to its substrate, Florida perforate cladonia is susceptible to high winds, which may result in fragments being carried out of suitable habitat and reduce the species' ability to maintain itself (Yahr 2000c, NatureServe 2006). In 1995, Hurricane Opal had winds in excess of 100 miles-per-hour and caused storm surge over 20 feet (6 m) in the vicinity of populations on Santa Rosa island; two of the three subpopulations were extirpated and a third subpopulation was reduced by more than 70% (Yahr 1997, 2000c, 2003). Several additional hurricanes and tropical storms have affected Santa Rosa Island since Opal, the most notable being Hurricane Ivan (category 3) in 2004 (Eglin 2004b, 2006). A significant amount of sand had shifted within the dunes supporting the lichen and the area had been inundated by water and contained a considerable amount of debris, prompting rescue efforts to unbury as much lichen as possible within a two day span (Eglin 2004b). Overall an estimated 40% of the population was lost due to the storm surge and coverage by sand and debris (Eglin 2006). Future hurricanes in Florida along the North Gulf Coast and Atlantic Coast continue to place populations at risk. (USFWS, 2007)

Stressor: Intrinsic factors and low genetic diversity (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Intrinsic factors including limited dispersal, slow growth rates, population fluctuations, and restricted range are also threats to this species (Yahr 2003). Yahr (1997) suggested that local patches or isolated mats that are destroyed by locally severe disturbances can be recolonized and recover only from a relatively local source if intervening barriers to dispersal do not exist (e.g., litter impedes or prevents movement of fragments, surface or standing water kills fragments). Increasingly fragmented and isolated scrub habitats coupled with periodic natural disturbances can be catastrophic (Yahr 1997). For example, the extirpation of a small isolated population may not be recoverable because of larger breaks in suitable habitat and limited dispersal (Yahr 1997). Populations exposed to repeated catastrophic losses (e.g., hurricanes in coastal areas, fires in inland areas) may no longer have a local source from which to disperse and thus, be at a higher risk of extinction (Yahr 1997). The species' poor dispersal and patchy distribution make it inherently vulnerable to extinction from large-scale disturbances (Yahr 1997). Historical population bottlenecks and resulting low genetic diversity are a concern (Yahr

and DePriest 2005). Since each population is predominantly clonal, variability can only be protected by protecting multiple, genetically different, populations (Yahr and DePriest 2005). However, despite the low number of genotypes and strong spatial structure, Yahr and DePriest (2005) suggest that populations are likely to be stable under natural disturbance regimes. Yahr and DePriest (2005) believe that the overall risks from demographic factors appear low compared to those associated with habitat loss and improper management. (USFWS, 2007)

Stressor: Air pollution (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: many lichens are sensitive to air pollution, and the IUCN redlist lists atmospheric pollution as a major threat to the species and / or its habitat (Yahr 2003). In general, lichens are sensitive to gaseous pollutants, especially sulfur dioxide, nitrogen oxides, ozone, and fluorine (Blett et al. 2003). Lichens are also sensitive to depositional compounds, particularly sulfuric and nitric acids, sulfites and bisulfites, and other fertilizing, acidifying, or alkalinizing pollutants (Blett et ni. 2003). Yahr and DePriest (2005) acknowledge that lichen sensitivity to air pollution presents a difficult management issue since air- and wind-borne pollutants cross management and jurisdictional boundaries. The extent to which Florida perforate cladonia and its habitat may be affected by air pollution is not known at this time. (USFWS, 2007)

Recovery

Reclassification Criteria:
1. When enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to assure 20 to 90 percent probability of persistence for 100 years (USFWS, 1999)

2. When these sites, within the historic range of C. perforata, are adequately protected from further habitat loss, degradation, and fragmentation (USFWS, 1999)

3. When these sites are managed to maintain the rosemay phase of xeric oak scrub communities to support C. perforata (USFWS, 1999)

4. When monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species. (USFWS, 1999)

Delisting Criteria:
1. When at least 40 populations exhibit a stable or increasing trend, evidenced by natural recruitment and multiple size classes. (Factor A) (USFWS, 2019)

2. When populations (as defined in criterion 1) occur in white sand rosemary and sand pine scrub habitats and are distributed across the historical range of the species. (Factor A) (USFWS, 2019)

3. When populations (as defined in criterion 1) must be protected via a conservation mechanism and/or managed such that enough suitable habitat is present for the species to remain viable for

the foreseeable future. (Factors A, D, and E) (USFWS, 2019)

Recovery Actions:

- 1. Determine current distribution of C. perforata. This species' known distribution is scattered from the panhandle area of Florida south to Martin and Palm Beach counties in South Florida with large areas having no individuals. A thorough survey is needed to determine the distribution for this species. (USFWS, 1999)
- 2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats. (USFWS, 1999)
- 3. Conduct research on life history characteristics of C. perforata. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed. (USFWS, 1999)
- 4. Monitor existing populations of C. perforata. - Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for herbivory, disease and injury. - Monitor the effects of various land management actions on C. perforata. - Develop a quantitative description of the population structure of C. perforata. (USFWS, 1999)
- 5. Provide public information about C. perforata. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about where C. perforata is found. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of C. perforata and other rare species requires a self-sustaining, secure, number of natural populations. (USFWS, 1999)
- Habitat-level Recovery Actions: - Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Restore areas to suitable habitat. Conduct habitat-level research projects. Monitor habitat/ecological processes. Provide public information about scrub and its unique biota. (USFWS, 1999)
- Secure land that supports this species where possible (Service 1999, Yahr and DePriest 2005, Turner et al. 2006). Protect populations on private land through acquisition, conservation easements, or agreements with landowners (USFWS, 2007)
- Protect populations on public lands. Include specific management goals and objectives for Florida perforate cladonia in management plans for State and Federal lands and other protected areas (H. Swain, pers. comm. 2007). Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages including fire frequency, lighting practices, fire intensity, and avoidance (Service 1999; Yahr 2000a; A. Cox, pers. comm 2007; H. Swain, pers. comm. 2007). Public lands with potential for wildfire incidents should have preexisting plans in place to support decision making the day of the event. (USFWS, 2007)
- Protect multiple, genetically different, populations (Yahr and DePriest 2005).(USFWS, 2007)

- Prevent loss, modification, and degradation of existing habitat.(USFWS, 2007)
- Avoid overly regular fire regimes, fire suppression, or burning too frequently and encourage a mosaic of times since fire for each habitat type (Menges and Kohfeldt 1995, Yahr 2000a). Encourage patchy burns in rosemary scrub (H. Swain, pers. comm. 2007).(USFWS, 2007)
- Maintain unburned refugia during prescribed fire and low-fuel patches that do not carry fire; these are critical refugia for this species and must be maintained for subpopulations to persist (Yahr 2000a, 2003). If effective means of protecting refugia are developed, coordinate with conservation and land management entities to ensure further protection of refugia (K. Clanton, pers. comm. 2007).(USFWS, 2007)
- Quantify (using GIS analysis) the degree to which current fire practices are providing a mosaic of unburned and burned patches, based on available fire intensity maps and burn histories; adjust fire regime and prescribed fire guidelines based on these results (H. Swain, pers. comm. 2007).(USFWS, 2007)
- Protect all sites from vehicle or heavy foot traffic (Service 1999). Limit access and prevent ORV traffic in public areas where this species occurs (FNAI 2006). Monitor and evaluate the impact of vehicle or heavy foot traffic (H. Swain, pers. comm. 2007).(USFWS, 2007)
- Maintain coastal scrub habitat; patches of stable vegetation that are resistant to wind and water erosion from hurricane overwash may serve as refugia (Yahr 1997).(USFWS, 2007)
- Monitor existing populations. Detailed monitoring information from most populations is largely absent. Monitor to detect changes in population status and to assess the effects of land management actions on this species. Monitoring burned sites that formerly supported the species would be particularly useful to understand how well and how quickly the species recovers after fire so the risks of burning areas where it occurs can be assessed accurately (A. Johnson, pers. comm. 2007).(USFWS, 2007)
- Establish and implement a feasible and statistically-reliable monitoring protocol (R. Yahr, pers. comm. 2007).(USFWS, 2007)
- Convene an expert group to develop standardized monitoring practices, facilitate summary information, and compare long-term trends across sites in relation to fire management and other management practices (H. Swain, pers. comm. 2007).(USFWS, 2007)
- Share monitoring protocols with administrators and other appropriate personnel within each cooperating entity to ensure wider appreciation and application of these protocols. Such staff should include all those active in land management decisions and those responsible for the application of land management (K. Clanton, pers. comm. 2007).(USFWS, 2007)
- Convene an expert group to determine the key components of population biology and demographic processes that can, and should, be measured (H. Swain, pers. comm. 2007). Continue research to determine demographic information (Service 1999; K. Clanton, pers. comm. 2007). Determine what demographic data are needed to conduct population viability and risk assessment analyses, then collect data and conduct analyses (H. Swain, pers. comm. 2007). Rigorous sampling methods need to be developed and consistently applied (R. Yahr, pers. comm. 2007).(USFWS, 2007)
- Expand work to better understand genetics, genetic variation, and trends in genetic variation. Based on an analysis of 16 populations across three regions of Florida, Yahr (pers. comm. 23 2007) has found strong evidence for fungal clonality within sites and evidence for differences among geographic regions. These data are not yet published, but should be available soon (R. Yahr, pers. comm. 2007).(USFWS, 2007)

- Conduct surveys for additional populations. It appears that there are data gaps in Manatee and Polk Counties. There may be additional populations that have not been located, especially in central Florida and on the east coast (A. Cox, pers. comm. 2007). In addition, scrub and high pine habitat in Osceola, Hardee, and Hendry Counties should be surveyed for possible occurrences and potential habitat (Service 1999). Since this species has never been reported from these counties, it might be more productive to make sure that biologists and land managers are informed of what this species looks like so that they can report any new occurrences (A. Johnson, pers. comm. 2007).(USFWS, 2007)
- Restore areas to suitable habitat and restore natural fire regimes. Explore restoration techniques to assess effective practices for Florida perforate cladonia (H. Swain, pers. comm. 2007). Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves; depending on fire management needs (Service 1999).(USFWS, 2007)
- Determine if pathogens or mold are threats to Florida perforate cladonia in its natural environment, following hurricanes, tropical storms, or other flooding events.(USFWS, 2007)
- Continue safe haven population efforts at HBS with collections from other sites or across the range of the species; this project should be carefully monitored in light of its poor survival rate (R. Yahr, pers. comm. 2007). If more lichen will be transported for ex-situ conservation, individuals must be grown on extremely well-drained white sand collected from a native source (R. Yahr, pers. comm. 2007).(USFWS, 2007)
- Continue to provide the public with educational information about scrub and its unique biota (Service 1999). This is especially important at Eglin, where the largest population is quite susceptible to trampling and damage from vehicular access (R. Yahr, pers. comm. 2007). Yahr (pers. comm. 2007) states that two parts of this education process must be considered, authorities and the public. Yahr (pers. comet. 2007) states that is imperative that local authorities and contractors are made aware of the delicate nature of lichen habitats. Boardwalks and informational panels describing the delicate dune habitats should be provided, and access limited as much as possible by encouraging the use of well-maintained trails, boardwalks and beach facilities (R. Yahr, pers. comm. 2007).(USFWS, 2007)
- Consider translocating "individuals" (e.g., whole individuals, fragments) from each of the four geographical areas to other regions to increase genetic diversity within each region, using great caution so as to not inadvertently transfer noxious biological agents such as molds or pathogens (K. Clanton, pers. comm. 2007). Consult with experts on Florida perforate cladonia (i.e., Yahr and DePriest) prior to planning and implementing (K. Clanton, pers. comm. 2007). (USFWS, 2007)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS A detailed discussion of recovery actions and criteria are presented in the Recovery Plan and amendment (Service 1999 and 2019, respectively). During this status review new and/or targeted potential recovery activities were identified and are included below. Recovery Activities • Identify areas of protected suitable habitat for introductions and establish new populations. • Restore scrub habitat within the range of each metapopulation (North Gulf Coast, West Coast, Lake Wales Ridge, and Atlantic Coastal Ridge) for potential introduction sites. • Continue and enhance management practices on conservation lands, including reduction of hardwoods, creation of sandy openings, targeted prescribed fire, and removal of invasive species. • Continue application of prescribed fire at sites that support the species while using protection

measures (e.g., clearing leaf litter away from lichen clumps, creating more burn units for small, patchy fires, temporarily removing lichen from burn units, etc.) to prevent harm. • Continue or enhance protections of populations on conservation lands from human disturbances (e.g., ATV use, trampling, etc.). • Protect populations and suitable habitat on private land through acquisition, conservation easements, or agreements with landowners. • Conduct outreach to private landowners to increase awareness of sites where the lichen is present within the Lake Wales Ridge and Atlantic Coastal Ridge and to reduce ATV use and trash dumping. Encourage and assist with land management activities (reducing hardwoods, removing invasive species) on these private sites to benefit the species. • Consider translocating populations in danger of extirpation from human disturbance or development to protected sites, either augmenting current populations or establishing new ones. • Continue efforts to develop a complete ex situ tissue bank collection from each metapopulation. Monitoring/Research Activities • Continue regular monitoring at ABS, LWRWEA, and LWRSF to record the presence/absence, abundance, percent cover, and habitat conditions. Add information on natural recruitment and size classes. • Conduct regular monitoring at all other known populations on managed lands following or adapting monitoring protocols used at the ABS, LWRWEA, and LWRSF populations. Also include information on natural recruitment and size classes. • Expand work to better understand genetic variation and the importance of clonality. • Conduct presence/absence surveys in areas of suitable habitat within and between the metapopulations to discover new populations or to verify the species is not likely present. Most suitable habitat along the Atlantic Coastal Ridge was surveyed in 2009 and 2011, but some areas are still in need of surveys (Richardson and Moore 2009, 2011). During the 2020 statewide survey, researchers visited some suitable habitat where the lichen had not been documented in the Lake Wales and Atlantic Coastal Ridges (Herring 2021), but many areas should still be surveyed, especially on the northern end of the Lake Wales Ridge in Osceola, Orange, Lake, and Marion counties. • Provide land managers of suitable habitat with the identification key for Florida lichens (Rosenterter et al. 2015) so they can report any new occurrences to the Service. (USFWS, 2021)

References

USFWS. 2007. Florida perforate cladonia (Cladonia perforata), 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, South Florida Ecological Services Office. 32 pp. September 2007. https://ecos.fws.gov/docs/five_year_review/doc1095.pdf

USFWS. 1999. Florida Perforate Cladonia Revised Recovery Plan (May, 1999). Pages 4-887 to 4-900, In: South Florida Multi-Species Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. https://www.fws.gov/verobeach/MSRPPDFs/FLPerforate.PDF

USFWS. 2019. Amendment 1. Recovery Plan for the Cladonia perforate (Florida perforate cladonia). U.S. Fish and Wildlife Service, Atlanta, Georgia. 6 pp. September 24, 2019.

USFWS. 1999. Florida Perforate Cladonia Revised Recovery Plan (May, 1999). Pages 4-887 to 4-900, In: South Florida Multi-Species Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. https://www.fws.gov/verobeach/MSRPPDFs/FLPerforate.PDF

USFWS. 2021. Florida perforate cladonia (Cladonia perforata) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service South Atlantic-Gulf Region Florida Ecological Services Field Office Vero Beach, Florida. 25 pp.

SPECIES ACCOUNT: *Cupressus goveniana ssp. goveniana* (Gowen cypress)

Species Taxonomic and Listing Information

Listing Status: Threatened; Pacific Southwest (R8) (USFWS, 2015)

Physical Description

A small, sparsely branched coniferous tree, usually 5-7 m tall and 2-4 m wide at the crown. Foliage is scale-like, pale green to yellow-green in color. Seed cones are round, 1-1.5 cm long, woody; they remain closed for many years, typically opening and releasing seeds during fires (NatureServe, 2015).

Taxonomy

In the second edition of the Jepson Manual (Baldwin et al. 2012) what Kartesz (1994 and 1999) treated as Cupressus goveniana ssp. goveniana and C. goveniana ssp. pygmaea are treated as distinct species in the genus Hesperocyparis (NatureServe, 2015).

Historical Range

The historical extent of the two extant stands is not known (USFWS 2008) (NatureServe, 2015).

Current Range

Restricted to two sites approximately 6.4 km apart on the Monterey Peninsula, coastal Monterey County, California. Suitable habitat for this species is very limited in extent (USFWS 2008) (NatureServe, 2015).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Reproductive Strategy

Adult: Sexual (inferred from NatureServe, 2015)

Lifespan

Adult: 85 - 127 years (USFWS, 2012)

Key Resources Needed for Breeding

Adult: Frequent fires, wind (NatureServe, 2015); open canopy (USFWS, 2008); bare mideral soils (USFWS, 2012).

Reproduction Narrative

Adult: Has adaptations typically associated with frequent fires: Female cones are serotinous (only opening to release seeds when exposed to very high heat or fire) and may be produced on a tree as young as four years. Mass synchronized openings of the serotinous cones during fires

are likely a critical part of its natural regeneration process (USFWS 2008). Pollination occurs via wind. Recruitment rates are very low in maritime chaparral habitat due to the high vegetation density; this (sub)species will not germinate in shade (USFWS 2008). (NatureServe, 2015). Hesperocyparis goveniana is a long-lived species (85-127 years). H. goveniana also needs light and bare mineral soils for seedling establishment. Recruitment rates for the species are extremely low in maritime chaparral habitat due to the high density of vegetation and the intolerance of this species to germinate in a shaded environment (Doak et al. 2000). Recruitment is higher, but still low, in mixed conifer habitat (Doak et al. 2000) (USFWS, 2012).

Habitat Type

Adult: Terrestrial (NatureServe, 2015)

Habitat Vegetation or Surface Water Classification

Adult: Coniferous forest, pygmy forest, maritime chaparral (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: Natural fire regime (see reproduction narrative)

Geographic or Habitat Restraints or Barriers

Adult: Occurs at 30 - 300 m elevation; restircted to Monterey coast (NatureServe, 2015)

Environmental Specificity

Adult: Very narrow (Natureserve, 2015)

Tolerance Ranges/Thresholds

Adult: Mderate (inferred from USFWS, 2012)

Habitat Narrative

Adult: Closed-cone coniferous forest, pygmy forest, and maritime chaparral habitats; may occur in pure stands or in mixed stands with Monterey pines or Bishop pines (Pinus muricata). An understory of chaparral shrubs is often present. Apparently restricted to shallow Cieneba or podzolic soil types with severely reduced nutrient availability, which precludes establishment by other trees. Occurs at 30 - 300 m elevation. The nevironmental secificity is very narrow; this (sub)species' adaptation to a very specific soil type essentially restricts it to its current distribution on the Monterey coast (USFWS 2008) (NatureServe, 2015). While H. goveniana can grow in a variety of habitats with minor disturbances, it apparently requires mineral soil surfaces and unshaded conditions for successful recruitment (Doak et al. 2000) (USFWS, 2012).

Dispersal/Migration

Dispersal

Adult: Low (USFWS, 2012)

Dispersal/Migration Narrative

Adult: Natural seed dispersal occurs during September and October, although seeds are not light enough to be carried far from the parent plant (Sudworth 1967) (USFWS, 2012). Seeds are dispersed upon mechanical removal from the tree, death of the tree or supporting branch, when heat from fire breaks the cones' resinous seal and allows seeds to escape, or during hot, dry

weather (USFWS, 2004).

Population Information and Trends

Population Trends:
Not available

Species Trends:
Stable (NatureServe, 2015)

Number of Populations:
2 (USFWS, 2021)

Adaptability:
Low (inferred from NatureServe, 2015)

Population Narrative:
In the absence of fire, lack of recruitment becomes a major issue for this (sub)species. During the last glacial era, it is believed that the temperate coastal climate was more favorable for conifers; increasing aridity since then probably contributes to the restriction of this (sub)species to a few coastal sites. The U.S. Fish and Wildlife Service counts only 2 occurrences, one at the Del Monte Forest within the Morse Botanical Reserve, and one at Point Lobos State Reserve (USFWS 2002). The California Natural Diversity Database (2008) reports a third occurrence of less than 10 plants on private land < 1 km south of the Del Monte Forest; it appears that USFWS considers these plants part of the Del Monte Forest stand. Estimated stable by USFWS in April 2003 (NatureServe, 2015).

Threats and Stressors

Stressor: Development (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The species was listed as threatened in 1998 primarily due to habitat loss, fragmentation, and secondary impacts from development of privately owned land contiguous with what is now known as the Huckleberry Hill stand. This threat continues, as proposals for additional development of residential neighborhoods and resort areas are currently under review by the County of Monterey, and will result in the increase of urbanization adjacent to the Del Monte Forest population. Current development proposals will likely continue to encroach on habitat that is already surrounded by urbanized areas. Similar encroachment can be seen around the Point Lobos population, where properties immediately surrounding the Ranch continue to be developed (K. Barry, pers. obs. 2011b). The proximity of permanent structures and human habitation is likely to impede future management of both populations. With no room for the Del Monte Forest population to expand because of planned development, increasing the size of both populations, as called for in the Recovery Plan, will remain a challenge to the land managers. Existing development allowed on the immediate edge of occupied habitat, such as that along the upper ridge of Huckleberry Hill, constrain active management techniques (such as prescribed burning) that are likely to be necessary in the future (USFWS, 2013).

Stressor: Erosion (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: In 2007, observations at the Del Monte Forest stand indicated that activity from hikers and mountain bikers was causing considerable and damaging erosion (C. West, pers. obs. 2007). The Pebble Beach Company acknowledged that they did not have the personnel resources necessary to patrol or enforce trespassing and mountain biking restrictions on these portions of its property (E. Love, pers. comm. 2007). Trails were cut through the surrounding area and even entered the stand itself. Mountain bike jumps and bridges made from cut tree trunks from within the stand were also visible throughout the area (C. West, pers. obs. 2007). Remnants of old, cleared ranch roads total 5.9 percent of the Point Lobos stand (T. Moss in litt. 2011). Removal of anchoring vegetation and poor drainage in these areas have allowed the topsoil to be completely washed away in much of the road system and caused severe erosion in the surrounding habitat (Figure 1) (T. Moss in litt. 2011; C. West, pers. obs. 2007). Continued flushing with surface water during rains prevents soil accumulation and vegetation establishment. Water seeping from the soil layer upslope of one of these exposed areas, or water falling as rain onto an exposed area, is not slowed by soil or vegetation, and therefore accumulates and behaves like a stream. Upon reaching natural drainages, this swift-moving water cuts deep ravines, further removing the limited topsoil and eroding habitat (T. Moss in litt. 2011; K. Barry, pers. obs. 2011a; C. West, pers. obs. 2007) (USFWS, 2013).

Stressor: Invasive species (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: At the time of listing, displacement by invasive species was considered a key threat. While this threat remains, the Pebble Beach Company regularly works to control problem species in the Hesperocyparis goveniana stand (E. Love, pers. comm. 2011). In 2011, no pampas grass was observed at either population of H. goveniana, and while considerable numbers of French Broom were present at both occurrences, they were all small, recently-recruited individuals that germinated between removal projects (K. Barry, pers. obs. 2011a). These control efforts are critical to the persistence of H. goveniana, and will need to be continued for the foreseeable future (USFWS, 2013).

Stressor: Disruption of natural fire cycles (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The disruption of natural fire cycles was considered a primary threat at the time of listing and remains a major and continuing threat to this species (V. Yadon in litt. 2002; Jones and Stokes Associates 1996). As succession continues and native chaparral along with nonnative species fill in as understory, the availability of bare soil exposed to direct sun, which this taxon requires for establishment, will be reduced. Fire is necessary to clear the understory and litter layers and remains the best management tool for maintaining Hesperocyparis goveniana habitat (Jones and Stokes Associates 1996). As mentioned previously, development continues to encroach and surround H. goveniana habitat, and the ability to safely and effectively use fire as a

management tool has been greatly reduced. Jones and Stokes Associates (1996) found that existing development surrounding the Del Monte Forest likely precludes the use of fire as a management tool. At the time of listing, accumulation of understory litter leading to lower recruitment was not considered a major threat to this species. Currently, recruitment seems to be occurring with frequency only at the Del Monte Forest population, where two fires in the past 60 years (1959, 1987) have cleared ground litter, understory, and canopy in portions of the stand allowing for regeneration of the species (K. Barry, pers. obs. 2011a). This threat will likely continue until the natural disturbance cycles can be restored or until adequate surrogates for natural disturbance factors are identified and implemented (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
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, Intergovernmental Panel on Climate Change (IPCC) 2007). Hesperocyparis goveniana's small and isolated range increases its vulnerability to random fluctuations in annual weather patterns and environmental disturbances such as can be brought about by climate change (USFWS, 2013).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. Monitoring of the Del Monte Forest population and the Point Lobos population for a minimum of 10 years (or longer if needed) shows long-term reproductive success in both populations. As determined by research, protected habitat must be of adequate size (large enough to support a functioning ecosystem, including areas that support suitable unoccupied habitat for population expansion and fluctuations in distribution) to ensure that ecosystem and community processes and associated species (e.g., hydrologic regime, fire, food webs, fauna, Monterey pine forest communities) are maintained, and that the locations are adequate to provide for population expansion and for colonization of new areas as microhabitat conditions change (USFWS, 2013).

2. Twelve or more years (or possibly as much as one generation) of monitoring have determined that successful recruitment has increased the overall size of both populations. Regeneration success should be measured in terms of abundant natural regeneration (with parental contributions from many trees for genetic purposes) and measured directly with genetic analysis if possible (USFWS, 2013).

3. A prescribed burn plan is established to improve surrounding habitat to reduce high vegetation cover and promote recruitment, or research has documented an alternative method to burning that is successful in promoting reproduction. Appropriate management to improve the surrounding habitat would need to be successfully implemented. Funds must be available for appropriate long-term management (USFWS, 2013).

4. A seed bank is established at a recognized institution certified by the Center for Plant Conservation (CPC). The seed bank is needed for protection of the species in case of an unforeseen naturally occurring event that would create a lack of reproduction or die-off from disease. Seeds should represent the remaining genetic diversity of the species and the viability (i.e., germination percentage) of the seed collection should be determined (USFWS, 2013).

Recovery Actions:

- Secure and protect existing populations and habitat on private or unprotected lands through willing landowners (USFWS, 2004).
- Manage lands to control or eliminate threats to the plants and their habitat (USFWS, 2004).
- Conduct research to document life history characteristics and plants' responses to vegetation management (USFWS, 2004).
- Survey for additional populations and suitable habitat for reintroduction or reestablishment and establish new populations (USFWS, 2004).
- Develop management strategies and monitor populations to determine effectiveness of management (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).
- Experiments should be undertaken to determine the effectiveness of mechanical clearing and controlled burns for the recruitment of young saplings. Any experiments conducted should include a genetic analysis component to determine the diversity of recruitment based on clearing method used (USFWS, 2013).
- Land managers should attempt to reclaim unused road and trail systems within existing stands. Restoration of these areas by replacing topsoil and planting native vegetation to anchor it in place could reduce erosion and increase the amount of suitable habitat within the existing stands. Within the Point Lobos stand, 0.46 hectares (1.1 acres) could be recovered, allowing recruitment to increase population size (USFWS, 2013).
- An effort should be made to determine where trees have been intentionally planted within the naturally occurring populations. For each of these plantings, it should be noted from where the seeds originated. All plantings should be undertaken from stock that derives from, and thus is genetically consistent with, the targeted planting area (USFWS, 2013).
- Genetic analyses should be undertaken to determine the relatedness of the two stands and a seed bank should be created by collecting seed from both stands and many individuals per site (USFWS, 2013).
- Any plans for trail construction or recreational public use at Point Lobos Ranch should only be considered if natural ecological processes within the stand will not be negatively impacted. In addition, no structures, fencing, signage, or other improvements should be installed near or within the stand that could hinder management activities, such as heavy equipment use, or prescribed burns (USFWS, 2013).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Conduct inventories of the Huckleberry Hill population and the Point Lobos Ranch population including age structure of each stand and recruitment through time. Inventories should also include associated information such as co-

occurring vegetation and amount of available space for colonization. Inventories should be conducted every five years or at an interval such that meaningful comparisons can be made. 2. Conduct research to evaluate whether a more general ground disturbance may replace fire in order to encourage recruitment. It is unlikely that prescribed fire will be an acceptable management tool so additional strategies are needed. 3. Evaluate inter- and intra- population genetic diversity. 4. Establish a funded seed collection with seed from both populations, representing the majority of the genetic diversity of the species. (USFWS, 2021)

References

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

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

USFWS. 2015. Environmental Conservation Online System (ECOS) – Species Profile. http://ecos.fws.gov/ecp0/. Accessed April 2016.

USFWS 2012. Hesperocyparis [=Cupressus] goveniana Gowen cypress 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.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A." USFWS. 2021. Gowen Cypress (Hesperocyparis [=Cupressus] goveniana) 5-Year Review: Evaluation and Summary. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California. 13 pp.

USFWS. 2012. Hesperocyparis [=Cupressus] goveniana Gowen cypress 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California.

USFWS 2012. Hesperocyparis [=Cupressus] goveniana Gowen cypress

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 2012. Hesperocyparis [=Cupressus] goveniana Gowen cypress 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California.

USFWS. 2021. Gowen Cypress (Hesperocyparis [=Cupressus] goveniana) 5-Year Review: Evaluation and Summary. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office Ventura, California. 13 pp.

SPECIES ACCOUNT: *Donrichardsia macroneuron* (donrichard moss)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Donrichardsia macroneuron is an aquatic moss that grows on submerged or partially submerged rocks. The deep, loosely interwoven mats are blue-green to blackish-brown when shaded and yellow-green when exposed to full sun. The curving, rigid stems of gametophytes reach 3 to 14 centimeters (cm) (1.2 to 5.5 inches (in)) in length, with irregular branches up to 10 millimeters (mm) (0.4 in) long. Leaves are loosely erect and spreading when moist, dark green to brownish, 0.4 to 0.8 mm (0.02 to 0.03 in) wide by 0.9 to 1.8 mm (0.04 to 0.07 in) long, oblong-lanceolate to oblong-ovate, bluntly acute, obtuse, rounded, or notched at the apex, the margins serrulate in the distal half, and the lamina with multiple-layered streaks up to 5 cells thick. Pseudoparaphyllia are foliose, broadly rounded, with entire to irregularly serrulate margins. The strong, thick (160 to 200 microns (µm; 0.006 to 0.007 in)) costa is about one-third the width of the leaf base, elliptical in cross-section, often laterally spurred, and may terminate just before reaching the apex or extend into a cuspidate point. Up to 4 perigonia per cm occur in the axils of vegetative leaves; perigonial leaves are 500 to 900 µm (0.02 to 0.04 in) long, ovate, acuminate, the costa lacking or extending only to the midpoint. From 8 to 12 antheridia arise from the base of perigonial leaves. Antheridia are about 300 µm (0.01 in) long and are surrounded by filiform paraphyses 7 to 8 cells long. Archegonia and sporophytes have not been observed in D. macroneuron. See Figure 1. (USFWS, 2018)

Taxonomy

Eula Whitehouse, a Texas bryologist, first collected D. macroneuron in 1932. Grout (1933, pp. 1−2) described this moss as a new species in the family Amblystegiaceae. D. macroneuron resembles Hygroamblystegium noterophilum, another relatively large aquatic moss with broad costa, but its linear-flexuose upper median leaf cells, short apical cells, and serrulate leaf margins distinguish it from the latter species (Crum 1969, p. 243). The morphology of sporophytes provides important clues for the taxonomic classification of mosses. Since neither archegonia nor sporophytes of this moss have been observed (see Figure 1 and Appendix A), its classification remained uncertain, and has been revised several times (Wynns et al. 2009, p. 800; see Table 1). Wyatt and Stoneburner (1980) collected and cultured live specimens from the type location. The cultured plants produced antheridia after 4 months, but did not produce archegonia or sporophytes during an additional 12 months (p. 517). They also used numerical taxonomy to compare D. macroneuron with 16 other related mosses, based on 20 gametophyte and 10 sporophyte morphological characters (pp. 513−514). The most distinctive morphological character of D. macroneuron is its very broad costa (Grout 1933, p. 2; Crum 1969, p. 243; Wynns et al. 2009, p. 800; Ignatov 2015a and b, p. 435). They concluded, “On the major issue of the distinctiveness of D. macroneuron, the evidence is unequivocal: it is at least as distinct phenetically from Eurhynchium, Hygroamblystegium, and Amblystegium as any of those genera are from each other,” and supported its inclusion in the Amblystegiaceae (Wyatt and Stoneburner 1980 p. 518). (USFWS, 2018)

Current Range

The entire known geographic range of D. macroneuron is limited to two sites, Seven Hundred Springs and Redfearn, located about 5 km (3.1 mi) apart, on the South Llano River, in Edwards and Kimble counties, Texas (Figures 4 and 5). These populations are supported by spring flows and are both located within the Edwards-Trinity Aquifers and the South Llano River watershed (Figure 4). Seven Hundred Springs is within the Bluff Creek 12−digit Hydrologic Unit Code (HUC−12) sub-watershed, and the Redfearn Site was within the Little Paint Creek and Paint Creek HUC−12 sub-watersheds (Figure 5). Wyatt and Stoneburner (1980, pp. 514, 516) visited ten other springs in the Llano and South Llano River watersheds in 1978 and 1979, but found no additional populations. They apparently did not visit the Redfearn site. Wyatt and Stoneburner (1980, all) are the last botanists to observe and document the continued existence of this species. They summarized the species' viability, based on their observations in 1978 and 1979 (pp. 519−520): "Donrichardsia macroneuron is an example of an endemic moss that was probably much more widespread as recently as 10,000 B.P. Its present restriction reflects its gradual retreat to increasingly infrequent sites of rapidly flowing perennial springs over limestone in shaded, protected canyons on the edge of the Edwards Plateau. It now survives only where springs have never dried up, even during droughts as severe as the '7−year drought' recorded in 1950−1958 (Correll & Johnston 1970). This most prolonged drought in recorded regional history was confirmed to have dried up springs at most of the localities we searched for additional populations..." (USFWS, 2018)

Critical Habitat Designated

No;

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the South Llano springs moss (Donrichardsia macroneuron), an aquatic moss species from Edwards County, Texas. We are excluding the single unit of proposed critical habitat, and, therefore, no critical habitat is being designated for the South Llano springs moss. This rule adds the species to the List of Endangered and Threatened Plants and applies the protections of the Act to the species

Special Management Considerations or Protections

Life History

Food/Nutrient Resources

Lifespan

Adult: The only information we have on the lifespan of D. macroneuron is that mats survived for at least 16 months in propagation (Wyatt and Stoneburner 1980, p. 513, 517). (USFWS, 2018)

Reproduction Narrative

Adult: Mosses closely related to D. macroneuron reproduce both sexually and asexually. However, there is no evidence that sexual reproduction is occurring in the single remaining known site of occurrence as no plants with reproductive structures have been observed. Plants cultivated in captivity produced only male sexual structures. It is possible that the known population may be a clone of a single or a few male individuals and that sexual reproduction is

no longer possible for the species. (USFWS, 2018)

Habitat Type

Adult: Spring outflow

Habitat Narrative

Adult: D. macroneuron requires continual immersion in spring water with a high mineral content. Spring water discharge is dependent on the supply of water from the Edwards-Trinity Aquifer (see Section II.5). (USFWS, 2018) At Seven Hundred Springs, water flows from a large number of cavities at the base of a limestone bluff at the edge of the South Llano River (Figure 3). When last observed, D. macroneuron grew in the spring outflow partially submerged in shaded areas within a 10 m (33 ft) zone between the springs and the river below (Wyatt and Stoneburner 1980, p. 516). The observations at Seven Hundred Springs indicate that the species occurred in both shaded and exposed niches (Wyatt and Stoneburner 1980, p. 516). The water temperature was consistently 21.5° C (70.7° F) in June, and the pH ranged from 7.0 to 7.2 (Wyatt and Stoneburner 1980, p. 516). Associated vascular plant species included maidenhair fern (Adiantum capillus-veneris), southern shield fern (Thelypteris kunthii), water cress (Nasturtium oficinale), and members of the mint family (Lamiaceae) and composite family (Asteraceae) (Wyatt and Stoneburner 1980, p. 516). Associated moss species included Hygroamblystegium tenax and Eucladium verticillatum; the former species occurred “in more exposed, less submerged situations” and the latter “in more protected areas such as the small ‘caves’ in which springs originate,” (Wyatt and Stoneburner 1980, p. 517). Hyalella azteca, a common, widespread amphipod, occurs at very high densities within the moss mats (Wyatt and Stoneburner 1980, pp. 516, 517). Discharge records for Seven Hundred Springs, based on single annual measurements taken on varying calendar dates from 1939 to 1978, ranged from 310 liters per second (l/sec) (11.0 cubic feet per second (ft3 /s)) in 1952 and 1956 to 910 l/sec (32.1 ft3 /s) in 1975, and averaged 460 l/sec (16.3 ft3 /s) (Brune 1981, p. 174). Annual average flows, based on multiple measurements per year on varying dates in 1939 and from 1968 through 2016, ranged from 371 l/s (13.1 ft3 /s)) in 2014 to 868 l/s (30.7 ft3 /s) in 1973, and averaged 542 l/s (19.1 ft3 /s) (U.S. Geological Survey 2017a, p. 1). Figure 2 shows the latter set of spring flow data overlaid on average annual precipitation from four weather stations (shown in Figure 4) that are within or near the South Llano River watershed (National Oceanic and Atmospheric Administration 2017, p. 1). Table 3 shows a comparison of discharge for Big Paint Spring, Seven Hundred Spring, and Tanner Springs, and the North Llano and Llano Rivers (USFWS, 2023).

Dispersal/Migration

Population Information and Trends

Number of Populations:

1 extant (USFWS, 2018)

Population Size:

1? (USFWS, 2018)

Population Narrative:

The entire known geographic range of D. macroneuron is limited to two sites, Seven Hundred Springs and Redfearn, located about 5 km (3.1 mi) apart, on the South Llano River, in Edwards

and Kimble counties, Texas (Figures 4 and 5). These populations are supported by spring flows and are both located within the Edwards-Trinity Aquifers and the South Llano River watershed (Figure 4). Seven Hundred Springs is within the Bluff Creek 12−digit Hydrologic Unit Code (HUC−12) sub-watershed, and the Redfearn Site was within the Little Paint Creek and Paint Creek HUC−12 sub-watersheds (Figure 5). Wyatt and Stoneburner (1980, pp. 514, 516) visited ten other springs in the Llano and South Llano River watersheds in 1978 and 1979, but found no additional populations. They apparently did not visit the Redfearn site. Furthermore, since only male individuals have been observed, the entire population may consist of clones of a single individual (an effective population size of 1). (USFWS, 2018)

Threats and Stressors

Stressor: Flash Floods (USFWS, 2018)
Exposure:
Response:
Consequence:
Narrative:

Stressor: Silt Deposition (USFWS, 2018)
Exposure:
Response:
Consequence:
Narrative:

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
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References

USFWS. 2018. Species status assessment of Donrichardsia macroneuron (Grout) H. A. Crum & L. E. Anderson. U.S. Fish and Wildlife Service Southwest Region, Albuquerque, New Mexico. 51 pp. + 2 appendices.

USFWS. 2018. Species status assessment of Donrichardsia macroneuron (Grout) H. A. Crum & L. E. Anderson. U.S. Fish and Wildlife Service Southwest Region, Albuquerque, New Mexico. 51 pp. + 2 appendices. USFWS. 2023. Species status assessment of Donrichardsia macroneuron (Grout) H. A. Crum & L. E. Anderson. U.S. Fish and Wildlife Service Southwest Region, Albuquerque, New Mexico. Version 1.1. 48 pp. + 3 appendices.