Appendix C: Plants

Lichens

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:

16 (USFWS, 2007)

Population Size:

2600 or greater individuals (USFWS, 2007)

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.

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)

Conservation Measures and Best Management Practices:

- 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)

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SPECIES ACCOUNT: *Gymnoderma lineare* (Rock gnome lichen)

Species Taxonomic and Listing Information

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

Physical Description

Gymnoderma lineare occurs in rather dense colonies of narrow straps (squamules). The only similar lichens are the squamulose species of the genus Cladonia. Gymnoderma lineare has terminal portions of the strap-like individual lobes that are blue-gray on the upper surface and generally shiny white on the lower surface; near the base the grade to black (unlike squamulose Cladonia, which are never blackened toward the base) (Weakley 1988, Hale 1979) (USFWS, 1997). A fruticose lichen in Cladoniaceae. (NatureServe, 2015)

Taxonomy

Gymnoderma lineare occurs in rather dense colonies of narrow straps (squamules). The only similar lichens are the squamulose species of the genus Cladonia. Gymnoderma lineare has terminal portions of the strap-like individual lobes that are blue-gray on the upper surface and generally shiny white on the lower surface; near the base the grade to black (unlike squamulose Cladonia, which are never blackened toward the base) (Weakley 1988, Hale 1979) (USFWS, 2013).

Historical Range

As of the 1997 recovery plan (USFWS 1997), 35 populations were known to exist; these populations occurred in North Carolina (25), Tennessee (7), Georgia (1), South Carolina (1), and 1 straddled the state line between North Carolina and Tennessee. Five populations were thought to have been extirpated (USFWS, 2013).

Current Range

Known to occur in the Smoky Mountains of North Carolina and Tennessee; also in South Carolina and Georgia (NatureServe, 2015). In 2012, the species' total range remains essentially the same, with the notable exception of a small population in Grayson County, Virginia (occupying an area of 6 square inches). Within the last 15 years, numerous populations have been discovered. The total number of known populations has increased from 35 to 85. These 85 are distributed across North Carolina (75), Tennessee (7), Georgia (1), South Carolina (1), and Virginia (1). Two of the five populations considered as extirpated in the recovery plan have been rediscovered. Of the remaining three, one was last observed in 1972 and has not been searched for since; another was last observed (despite surveys) in 1990, immediately prior to road construction that affected its habitat; and a third may be an erroneous report. This last population is reported from within the Great Smoky Mountain National Park (GSMNP), but the GSMNP botanist is not aware of the species' having occurred at this location (Janet Rock, GSMNP, personal communication, 2008). Three additional North Carolina populations counted in the listing rule (60 FR 3557) and recovery plan are not mapped in the North Carolina Natural Heritage Program database, and supporting information for these reports (other than a brief mention of the locality) is lacking. For purposes of this review, these three populations are regarded as potentially erroneous and have not been included in the tally of 85 known populations (USFWS, 2013).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Food/Nutrient Narrative

Adult: No information found

Reproductive Strategy

Adult: Asexual (USFWS, 1997)

Reproduction Narrative

Adult: The fruiting bodies (apothecia) are borne at the tips of the squamules and are black (contrasting to the brown or red apothecia of Cladonia spp.) (Weakley 1988). The apothecia are borne singularly or in clusters, usually at the tips of the squamules but occasionally along the sides; this have been found form July through September (Evans 1947, North Carolina Natural Heritage Program records 1991). The apothecia are either sessile or borne on short podetia 1 to 2 millimeters in height, and the largest of these have a diameter of about 1 millimeter, with most being much smaller. The apothecia are cylindrical in shape and radial in symmetry (Evans 1947). The primary means of propagation appears to be asexual, with colonies spreading clonally (USFWS, 1997).

Habitat Type

Adult: Cliffs (NatureServe, 2015)

Dependencies on Specific Environmental Elements

Adult: High Humidity (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist or community with ley requirements scarce (NarureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: On shady rock or shady moss-covered rock (Dey 1978). Further, it is "found in areas of high humidity, either on high-elevation cliffs, where it is frequently bathed in fog, or in deep river gorges at lower elevations. It is primarily limited to vertical rock faces, where seepage water from forest soils above flows at (and only at) very wet times, and large stream side boulders, where it receives a moderate amount of light but not high-intensity solar radiation" (Fish and Wildlife Service 2000). Threatened by habitat change especially due to loss of Fraser-fir forests and by heavy recreational use of its habitat. (NatureServe, 2015) This species is

specific to high humidity grantie cliffs. Its specific habitat needs infer high ecological integrity and site fidelity and low tolerance ranges (NatureServe, 2015)

Dispersal/Migration

Dispersal

Adult: Low (inferred from NatureServe, 2015; USFWS, 1997)

Dispersal/Migration Narrative

Adult: Lichens are non-migratoy with a low liklihood of dispersal and unlikely immigration/emigration based on the specific habitat needs of this species (NatureServe, 2015; USFWS, 1997).

Population Information and Trends

Population Trends:

Declining (USFWS, 2013)

Resiliency:

Low (inferred from USFWS, 2013; NatureServe, 2015 and USFWS, 1997)

Representation:

Low (inferred from USFWS, 2013; NatureServe, 2015 and USFWS, 1997)

Redundancy:

Low (inferred from USFWS, 2013; NatureServe, 2015 and USFWS, 1997)

Number of Populations:

85 (USFWS, 2013)

Population Narrative:

USFWS (2013) notes that populations level trends are declining and the number of known populations is 85. Low resiliency, representation and redundancy are inferred based on specific habitat needs of this species specific habitat requirements (inferred from USFWS, 2013; NatureServe, 2015 and USFWS, 1997)

Threats and Stressors

Stressor: Microclimate change (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: The death of Fraser-fir forests due to wooly adelgid infestation adjacent to the habitat where Gymnoderma lineare occurs has caused drastic changes in the local microclimate, including desiccation and increased temperatures (Federal Register, Jan. 18, 1995) (NatureServe, 2015).

Stressor: Human disturbance (NatureServe, 2015)

Exposure:
Response:
Consequence:
Narrative: "Threatened by trampling and associated soil erosion and compaction, other forms of habitat disturbance due to heavy recreational use of the habitat by hikers, climbers, and sightseers, as well as by development for commercial recreational facilities and residential purposes. Potentially threatened by logging, collectors, and air pollution (either directly or indirectly)." (Federal Register, Jan. 18, 1995.) Collection by scientists has had an impact on some small populations; 'this is one of the most unusual; endemic lichens in North America and should not be collected by individuals' (Hale 1979) (Southern Appalachian Species Viability Project 2002). (NatureServe, 2015)

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: An additional possible threat (climate change) has been identified (USFWS, 2013).

Recovery

Reclassification Criteria:
1. There are at least 30 populations stable over 5 years and within protective ownership (either on public land, such as parks and forests, wjere the managing agency is providing continuous monitoring and protection for the species, or on private land, where a long-term protection/management agreement with the owner is in place) (USFWS, 1997).

Delisting Criteria:
1. There are at least 40 populations stable for a minimum of 10 years (USFWS, 1997).

2. All of these populations are in protective ownership as defined in the downlisting criteria (USFWS, 1997).

Recovery Actions:
- Survey suitable habitat for additional populations (USFWS, 1997).
- Monitor and protect existing populations (USFWS, 1997).
- Conduct research on the biology of and threats to the species (USFWS, 1997).
- Establish new populations or rehabilitate marginal populations to the point where they are self-sustaining (USFWS, 1997).
- Investigate and conduct necessary management activities at all key sites (USFWS, 1997).

Conservation Measures and Best Management Practices:
- Work with all partners to conduct G. lineare surveys and obtain updated observation data at all known sites, beginning with those locations with the longest time period since last observed. Incorporate survey results in the appropriate state NHP databases. Encourage partners to use a standardized protocol for quantitative but rapid assessment of cover so that estimates of cover can be reasonably compared across sites and over time (USFWS, 2013).

- Search for additional occurrences of the species in sections of riparian corridors separating known occurrences and in the headwaters of streams located immediately below occupied high-elevation cliff habitat (USFWS, 2013).
- Research the species' habitat requirements to better understand periodic dieback of the lichen (USFWS, 2013).
- Quantitatively assess the impacts of recreational use and other threats to the species and its habitat (USFWS, 2013).

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