Florida perforate cladonia
(Cladonia perforata)

5-Year Review:
Summary and Evaluation

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U.S. Fish and Wildlife Service
South Atlantic-Gulf Region
Florida Ecological Services Field Office
Vero Beach, Florida

5-YEAR REVIEW
Florida perforate cladonia (*Cladonia perforata*)

I. GENERAL INFORMATION

A. Methodology used to complete the review:

In conducting this 5-year review, we relied on the best available information pertaining to historical and contemporary distributions, life histories, genetics, habitats, and threats of this species. This review includes information from the previous 5-year review (U.S. Fish and Wildlife Service [Service] 2007) that is still applicable to the species, with updated or new information incorporated, as appropriate. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period in 2018 (83 FR 38320). We received no public comments during the open comment period. We used a variety of information resources, including monitoring reports, surveys, and other scientific and management information, augmented by conversations and comments from biologists familiar with the species. Specific sources included the final rule (58 FR 25746; Service 1993) listing Florida perforate cladonia under the Endangered Species Act of 1973, as amended (ESA), the Recovery Plan (Service 1999), the last 5-year review (Service 2007), the recovery plan amendment (Service 2019), peer reviewed scientific publications, and unpublished field observations by Federal, State, and other experienced biologists. This review was conducted by a biologist in the Florida Ecological Services Field Office (FESFO), Vero Beach. Literature, documents, and correspondences used for this 5-year review are on file at the FESFO, Vero Beach. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on the Florida perforate cladonia. No part of the review was contracted to an outside party. The Service did not seek additional peer review for this updated 5-year review.

B. Reviewers

Lead Region: South Atlantic–Gulf Region, Carrie Straight, 404-679-7226

Lead Field Office: FESFO, Vero Beach, Heather Hitt, 772-469-4267

Cooperating Field Office(s): FESFO, Jacksonville, Todd Mecklenborg, 904-731-3336; FESFO, Panama City, Vivian Negron-Ortiz, 850-769-0552

C. Background

1. **Federal Register Notice citation announcing initiation of this review:** August 6, 2018, 83 FR 38320.

2. **Listing history**
   Original Listing
   FR notice: 58 FR 25746
   Date listed: April 27, 1993
   Entity listed: Species
   Classification: Endangered

3. **Associated rulemakings:** N/A

4. **Review History:** Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we performed a yearly recovery data call. The last review conducted in 2007 showed this species as declining with no change recommended to the species' status due to the continuing high threats such as the loss of scrub habitat from land conversion to agricultural and residential development, inadequate management, hurricanes, and anthropogenic disturbances (Service 2007).

   Recovery Plan: 1999
   Recovery Plan Amendment: 2019
   Previous Five-Year Review: 2007. This review recommended no change in status for the species.

5. **Species' Recovery Priority Number at start of review (48 FR 43098): 5C**
   Degree of Threat: High
   Recovery Potential: Low
   Taxonomy: Species
   The "C" reflects a degree of conflict with development activities.

6. **Recovery Plan**
   Name of plan: South Florida Multi-Species Recovery Plan (MSRP) (Service 1999)
   Date issued: May 18, 1999
   Date of recovery plan amendment: September 26, 2019 (Service 1999)
   Date of previous plan: June 20, 1996 (Recovery Plan for Nineteen Florida Scrub and High Pineland Plant Species) (Service 1996)

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

1. **Is the species under review listed as a DPS?** No. The definition of species under section 3 of the ESA includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPSs to only vertebrate species of fish and wildlife. Because the species under review is a listed as a plant, the DPS policy is not applicable.

B. Recovery Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes. An amendment to the 1999 recovery plan which revised the recovery criteria for Florida perforate cladonia was finalized in September 2019.

2. **Adequacy of recovery criteria.**

   a. **Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** Yes

   b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?** Yes

3. **List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.** The recovery criteria as presented in the 2019 amendment to the 1999 recovery plan are broken down into three criteria ([1-3] in bold below). These criteria address listing factors A) the present or threatened destruction, modification, or curtailment of its habitat or range; D) inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors affecting its survival. Factors B (overutilization for commercial, recreational, scientific, or educational purposes) and C (disease and predation) are not relevant to this species.

Florida perforate cladonia may be delisted when:

[1] At least 40 populations exhibit a stable or increasing trend, evidenced by natural recruitment and multiple size classes.
This criterion has not been met. Florida perforate cladonia is known to exist in four metapopulations, each within a distinct geographic region of Florida (North Gulf Coast, West Coast, Lake Wales Ridge, and Atlantic Coastal Ridge). Across these four regions there are currently 35 extant populations and 2 extirpated populations, many of which are divided into sub-populations (Table 1; Rosner-Katz 2019; Menges et al. 2020; Black Finch 2021; DeBolt 2021; Herring 2021; Moore 2021; Rosner-Katz 2021; Rossmanith 2021; Tate 2021; Ward 2021; van den Ende 2021). Detailed demographic data on natural recruitment or size classes are not being collected at any of the populations to determine trends, and only a few (10) populations are regularly monitored for abundance. For the populations that are not monitored regularly, status was estimated based on the best available data from land managers and researchers familiar with the populations. For the populations that are monitored regularly, status was estimated based on abundance data. When a population had multiple sub-populations with different statuses, the overall status was determined by the majority (or the largest sub-population's) status. Therefore, of the 35 extant populations, 14 are known (8) or estimated (6) to be increasing or stable, 9 are known (2) or estimated (7) to be declining, and 12 have an unknown status due to lack of recent survey data (4) or being newly discovered with only one survey event reported (8) (Table 1). Since the last review (Service 2007), 1 population and 6 sub-populations have

become extirpated (Table 1; Herring 2021; Ward 2021). Fourteen (14) new populations and 6 new sub-populations within known populations were discovered or introduced since the last review (Service 2007), though many are small, and some have even become extirpated by the time this review was conducted (Table 1).

[2] 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. (Factors A and E)
This criterion has been partially met. The 35 extant populations occur in white sand rosemary and sand pine scrub habitats across the historical range, which includes four distinct geographic regions of Florida (North Gulf Coast, West Coast, Lake Wales Ridge, and Atlantic Coastal Ridge). Surveys and introductions have increased the known range from three counties in the Lake Wales Ridge and North Gulf Coast regions at the time of listing (Service 1993) to seven counties throughout all four regions at the time of this review (Table 1). However, many acres of suitable habitat exist between populations and metapopulations which are either unoccupied by the species or have yet to be surveyed.

[3] 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, B, D, and E)
This criterion has been partially met. Twenty-seven (27) of the 35 known populations occur entirely on public or private conservation lands. About half (14) of these 27 populations are known or estimated to be stable or increasing (Table 1) due to ongoing habitat management efforts (invasive plant treatment, hardwood reduction, pine thinning, prescribed fire, etc.), though some populations and sub-populations on managed lands are declining due to impacts from prescribed fires (Menges et al. 2020; Ward 2021). Twelve (12) of the 35 populations occur entirely or partially on private lands with no known conservation mechanism in place. The status of most of these 12 populations is either unknown or declining due to all-terrain vehicle (ATV) use on site, trash dumping, or lack of habitat management and are in danger of being developed (Table 1).

C. Updated Information and Current Species Status

1. Biology and Habitat

a. New information on the species' biology and life history:

Florida perforate cladonia is a lichen (composite organism formed from a symbiotic relationship between algae and fungi) of the family Cladoniceae, commonly known as reindeer lichens. General information on the biology and life history of Florida perforate cladonia, also called Florida perforate reindeer lichen, is summarized in the Recovery Plan for Nineteen Florida Scrub and High Pineland Plant Species (Service 1996), the MSRP (Service 1999), and the previous 5-year review (Service 2007). A study by Richardson and Moore (2011) provided additional information on microhabitat conditions, growth rates, and dispersal of the lichen at a few sites on the Atlantic Coastal Ridge. Their results are summarized below.

Microhabitat Conditions

Like other lichen species, a positive relationship exists between humidity and weight of the lichen thalli (bodies or individuals), but as air temperatures increase throughout the day, the weight of the lichen thallus decreases due to desiccation, even on humid days (80 percent relative humidity; Richardson and Moore 2011). As the thalli dry out, they become brittle and are more susceptible to damage.

Florida perforate cladonia needs water to photosynthesize, and in most lichens, photosynthesis has been known to shut down when water content of the thallus goes below 30 percent (Peet and Adams 1972; Kranner et al. 2008). According to measurements of leaf wetness and photosynthetically active radiation levels available for the lichen in Richardson and Moore's 2011 study, photosynthetic activity would be highest for Florida perforate cladonia during the early morning daylight or for longer periods on overcast, humid days.

Florida perforate cladonia does best in full sun conditions and appears to decline when shaded. Richardson and Moore (2011) observed several mechanisms for preventing or delaying desiccation of the lichen thalli in open, sunny areas: 1) the thick thalli branches held water longer than thinner branched lichens; 2) lichens on wet sand held water longer than those on dry leaves; and 3) lichen thalli were observed drawing up water held in the rolled edges of overturned leaves of sand live oak (*Quercus geminata*) and Chapman's oak (*Q. chapmanii*).

Growth Rates

From February to December, Richardson and Moore (2011) documented a 70 percent average increase in thalli weight, with the greatest increases in the summer and fall. Several of the specimens with the greatest weight increases also showed visible signs of growth through elongation and widening of branches. Witmer (2014) reported similar growth rates, with an average of 79 percent increase in thalli weight and 10 percent increase in length over a two-year period at the Jupiter Ridge Natural Area. Major growth events did not occur during the same time period each year, but the lowest growth rates during both years occurred from March to May (Witmer 2014).

Dispersal

Florida perforate cladonia grows unattached to any substrate and is moved by wind, water, or animals (Rosentreter 1993; Yahr and DePriest 2005). Without spores or soredia (specialized long-distance dispersal units) found in some other lichens, dispersal of the large, bulky, vegetative Florida perforate cladonia thalli is limited (Yahr and DePriest 2005). Richardson and Moore (2011) observed that Florida perforate cladonia thalli were more easily windblown when dry since wet thalli are heavier and flex in the wind. Also, windblown lichens tended to disperse downslope and were halted by living plants, accumulations of leaf litter, woody debris, or small depressions caused by animal or human tracks. Wind speeds were not reported, but thalli placed in bare sand in mid-October moved between 9 and 16 meters (30 to 52 feet) within one month.

b. Abundance, population trends, and demography:

Florida perforate cladonia is known to occur within four metapopulations, each in a distinct geographic region of Florida (North Gulf Coast, West Coast, Lake Wales Ridge, and Atlantic Coastal Ridge). Across these four regions there are currently 35 populations, many of which are divided into sub-populations for a total of 55 sub-populations (Table 1). Since listing, the number of known populations has fluctuated from 4 with 12 sites or sub-populations at the time of listing (Service 1993), 27 sites or sub-populations in 1999 (the number of populations was not reported; Service 1999), 16 populations at the time of the last review (the number of sub-populations was not reported; Service 2007), and 41 sites or sub-populations reported in 2009-2011 (Richardson and Moore 2009, 2011).

Some of this fluctuation can be attributed to how populations were divided or not divided into sub-populations and what they were called (populations versus sites). For the purposes of this review, sites and sub-populations are synonymous; populations are made up of one or more sub-populations; and metapopulations are made up of one or more populations occurring in the same geographic region. Also, NatureServe's 1.0-kilometer (km) (0.62-mile) distance is used to differentiate populations, except in cases where unsuitable habitat occurs between populations that are closer (NatureServe 2020).

Limited detailed information is available regarding Florida perforate cladonia abundance, population trends, and demography because there is not an established monitoring program at most Florida perforate cladonia populations. Abundance data are difficult to compare to previous years and across populations due to differences in survey techniques, gaps in survey years (especially at populations or sub-populations on private lands), and variances in how boundaries were drawn between sub-populations by different surveyors.

The following is a summary of the best available information regarding the abundance and trends of Florida perforate cladonia populations across its range. A survey of suitable sites on the Atlantic Coastal Ridge in 2009 and 2011 reported the status of known and several newly discovered populations and sub-populations for that metapopulation (Richardson and Moore 2009, 2011). A statewide survey conducted by the Florida Natural Areas Inventory (FNAI) in 2020 (Herring 2021) updated abundance and status data for most populations, which was supplemented by land managers and researchers of populations on public and private conservation lands (Rosner-Katz 2019, 2021; Menges et al. 2020; Black Finch 2021; DeBolt 2021; Moore 2021; Rossmanith 2021; Tate 2021; Ward 2021; van den Ende 2021).

Table 1: Summary of the status of the extant and extirpated Florida perforate cladonia populations. Abundance data are difficult to compare to previous years due to differences in survey techniques, gaps in survey years, and varying sub-population boundaries, therefore, only the most recent population estimate is included in this table, and the status reflects the best estimates from land managers and researchers familiar with each population.

Metapopulation or Geographic Region	Population	Sub-population	County	Land Ownership	Most Recent Population Estimate	Date	Status
North Gulf Coast (West to East)	Santa Rosa Island	N/A	Escambia	Federal	0	1986[a]	Extirpated[a]
	Santa Rosa Island West	Restricted Beach - West	Okaloosa	Federal	>1,000	2020[b]	Stable[b]
	Santa Rosa Island West	Restricted Beach - East	Okaloosa	Federal	>1,500	2020[c]	Stable[b]
	Santa Rosa Island East	Public Beach	Okaloosa	Federal	>100,000	2021[c]	Stable[b]
West Coast (North to South)	Moody Branch Wildlife and Environmental Area *	N/A	Manatee	County	1 clump	2014[c]	Unknown
	Little Manatee River South Fork Tract	Northwest	Manatee	State	2,160 clumps	2020[c,d]	Declining[d]
	Little Manatee River South Fork Tract *	Southeast	Manatee	State	~2,000 clumps	2021[d]	Unknown
	Duette Preserve *	N/A	Manatee	County	90 clumps	2020[c,d]	Unknown
Lake Wales Ridge (North to South)	Lake Wales Ridge National Wildlife Refuge *	Lake McLeod Unit	Polk	Federal	Present	2021[e]	Unknown
	Sun Ray *	N/A	Polk	Private	105 clumps	2020[c]	Declining[c]
	Lake Wales Ridge State Forest - LA08	D	Polk	State	34.8% cover in 24 3-m plots	2019[f]	Stable to Increasing[f]
		C	Polk	State	64.2% cover in 86 3-m plots	2019[f]	Stable to Increasing[f]
		A	Polk	State	41.2% cover in 45 3-m plots	2019[f]	Stable to Increasing[f]
		E	Polk	State	29.9% cover in 20 3-m plots	2019[f]	Stable to Increasing[f]
		LA05	Polk	State	0	2021[g]	Extirpated[g]
	Lake Wales Ridge State Forest - BC07	B	Polk	State	52.9% cover in 9 3-m plots	2019[f]	Stable[f]
	Avon Park Lakes	N/A	Highlands	Private	50 clumps	2020[c]	Declining[c]
	College Scrub	N/A	Highlands	Private	Present	1995[d]	Unknown
	Lake Wales Ridge Wildlife and Environmental Area	Royce Unit RU6	Highlands	State	<100 fragments	2020[d]	Declining[d]
	Lake Wales Ridge Wildlife and Environmental Area	Royce Unit RU9	Highlands	State	1,000s	2020[d]	Stable[d]
	Archbold Biological Station	35	Highlands	Private Conservation	0	2021[d]	Extirpated[d]
		38	Highlands	Private Conservation	0	2021[d]	Extirpated[d]
		41	Highlands	Private Conservation	~10% cover in 90 48-cm plots	2020[d]	Declining[d]
		42	Highlands	Private Conservation	~22% cover in 82 48-cm plots	2020[d]	Stable[d]
		49	Highlands	Private Conservation	3-5% cover in 58 48-cm plots	2020[d]	Declining[d]
		50	Highlands	Private Conservation	~10% cover in 62 48-cm plots	2020[d]	Declining[d]

* indicates populations or sub-populations that were reported after the previous status review (Service 2007)

Table 1 Continued

Metapopulation or Geographic Region	Population	Sub-population	County	Land Ownership	Most Recent Population Estimate	Date	Status
Lake Wales Ridge Continued (North to South)	Archbold Biological Station Continued	51	Highlands	Private Conservation	0	2018[d]	Extirpated[d]
		60	Highlands	Private Conservation	<100 fragments	2021[d]	Stable[d]
		66	Highlands	Private Conservation	~8% cover in 41 48-cm plots	2019[d]	Declining[d]
		83	Highlands	Private Conservation	0	2021[d]	Extirpated[d]
		93	Highlands	Private Conservation	40-46% cover in 100 48-cm plots	2020[d]	Stable[d]
	Ben Hill Griffin Road	N/A	Highlands	Private	1,000s	1991[c]	Unknown
	Hendrie Ranch Florida Forever Proposal	North	Highlands	Private	Too numerous to count	1991[c]	Unknown
	Hendrie Ranch Florida Forever Proposal	South	Highlands	Private	Present	1986[c]	Unknown
	Fisheating Creek/ Smoak Groves Conservation Easement *	North	Highlands	Private Conservation	431 clumps	2020[c]	Unknown
	Fisheating Creek/ Smoak Groves Conservation Easement *	South	Highlands	Private Conservation	109 clumps	2020[c]	Unknown
Atlantic Coastal Ridge (North to South)	Harbor Branch Oceanographic Institute * [+]	N/A	St. Lucie	Private Conservation	>2,000	2019[h]	Stable to Increasing[h]
	Green River Pkwy *	N/A	Martin	County	5 clumps	2020[c]	Unknown
	Florida Inland Navigation District Site O-23 *	N/A	Martin	State	Present	2020[c]	Unknown
	Arbors Village Preserve Area	Arbors Village Preserve	Martin	Private Conservation	>100,000 fragments	2020[c]	Stable[c]
		Hobe Sound Executive Plaza *	Martin	Private	0	2020[h]	Extirpated[h]
		Scrub Oak/ Leopold Scrub	Martin	County	0	2020[c]	Extirpated[c]
	SE Osprey St *	N/A	Martin	Private	1,145 fragments	2020[c]	Declining[c]
	Atlantic Ridge Ecosystem	Lunn and Hobe Sound Marine Properties *	Martin	Private	3,024 fragments	2020[c]	Declining[c,h]
		Atlantic Ridge Ecosystem Florida Forever Proposal	Martin	State	1,120 fragments	2020[c]	Unknown
	Bridgetown Area	Vacation Motor Home Park *	Martin	Private	1,000s	2014[h]	Unknown
		Hobe Sound Publix Preserve	Martin	Private	70 fragments	2020[c]	Declining[c,h]
		Bridgetown	Martin	Private	10 fragments	2020[c]	Declining[c,h]
		Southeast Bridge Rd and Elenor Rd	Martin	Private	25 fragments	2020[c]	Declining[c,h]

* indicates populations or sub-populations that were reported after the previous status review (Service 2007)

[+] indicates introduced populations or sub-populations

Table 1 Continued

Metapopulation or Geographic Region	Population	Sub-population	County	Land Ownership	Most Recent Population Estimate	Date	Status
Atlantic Coastal Ridge Continued (North to South)	Pine School Area *	New Allen Temple Cemetery *	Martin	Private	4,000 fragments	2020[c]	Declining[c,h]
		St. Matthew Primitive Baptist Church *	Martin	Private	0	2020[c]	Extirpated[c]
		Pine School *	Martin	County	65 fragments	2020[c]	Unknown
		Pine School *	Martin	Private	5 fragments	2020[c]	Declining[c,h]
		South Martin Regional Utility *	Martin	Private	~10	2011[h]	Unknown
	Jonathan Dickinson State Park (JDSP) – North Central portion	N/A	Martin	State	430 individuals	2020[c,i]	Stable[i]
	JDSP – North of District Office *	N/A	Martin	State	15 clumps	2020[c]	Stable to Increasing[i]
	JDSP – Dunes along US Hwy 1 *	N/A	Martin	State	100 individuals	2020[c]	Increasing[i]
	JDSP - East portion	N/A	Martin	State	0	2020[c]	Extirpated[c]
	JDSP - South portion	Missile Tracking Annex	Martin	State	125 individuals	2020[c]	Declining[c,h]
		Sandy Pines Hospital *	Martin	State	2,500 individuals	2020[c]	Stable to Increasing[i]
		SE Tequesta Terrace	Martin	State	1,242 individuals	2020[c]	Stable[i]
		Riverside Memorial Cemetery *	Martin	Private	400 individuals	2020[c]	Declining[c,h]
	Jupiter Inlet Lighthouse Outstanding Natural Area	Lot 15 * [+]	Palm Beach	Federal	457-518	2021[j]	Increasing[j]
		Lot 19	Palm Beach	Federal	4,720 individuals	2020[c]	Increasing[j]
	Jupiter Ridge Natural Area	N/A	Palm Beach	County	>100,000	2021[c,k]	Stable[k]

***** indicates populations or sub-populations that were reported after the previous status review (Service 2007)

[+] indicates introduced populations or sub-populations

[a] Buckley and Hendrickson; [b] Tate 2021; [c] Herring 2021; [d] Ward 2021; [e] van den Ende 2021; [f] Rosner-Katz 2019; [g] Rosner-Katz 2021; [h] Moore 2021; [i] Rossmanith 2021; [j] DeBolt 2021; [k] Black Finch 2021

North Gulf Coast

Florida perforate cladonia was originally described from Santa Rosa Island in Escambia County in the Florida panhandle in 1945 (Evans 1952). The North Gulf Coast metapopulation currently consists of three populations at Eglin Air Force Base (AFB) on Santa Rosa Island in Okaloosa County (Table 1; Herring 2021; Tate 2021). This metapopulation is the most disjunct from the others, occurring approximately 515 km (320 miles) northwest of the next closest population. After Hurricane Opal in 1995, the two western-most populations, located on the restricted portion of the beach, were lost due to the storm surge, while as much as

half of the remaining population and habitat on the eastern public portion of the beach were impacted (Eglin AFB 2006). In 2000, two populations were reintroduced on the western side of Santa Rosa Island (Eglin AFB 2006). Despite impacts from other hurricanes, most notably Ivan in 2004 and Michael in 2018, all three populations on Santa Rosa Island have persisted and remain stable, and the largest is the eastern-most population with over 100,000 lichen thalli estimated (Table 1; Herring 2021; Tate 2021).

West Coast

Florida perforate cladonia was first reported in Manatee County in 1995 at the Southwest Florida Water Management District's (SWFWMD) Little Manatee River South Fork Tract (Service 1996, 1999). There are currently four populations within this metapopulation (Table 1). Two of these populations, Moody Branch Wildlife and Environmental Area and the southeastern population at the Little Manatee River South Fork Tract, were discovered recently (Table 1; Herring 2021; Ward 2021). The status of the population at the Florida Fish and Wildlife Conservation Commission's (FWC) Moody Branch Wildlife and Environmental Area is unknown since it has not been resurveyed since discovery in 2014. The two populations at the Little Manatee River South Fork Tract are reported as very large (about 2,000 clumps, or groups, of several individuals), but one is declining due to a recent prescribed fire and the other has an unknown status since it was recently discovered, though the habitat is becoming overgrown (Table 1; Ward 2021).

Lake Wales Ridge

Florida perforate cladonia was first reported in on the Lake Wales Ridge in Highlands County in 1968 (Moore 1968). The Lake Wales Ridge metapopulation currently consists of 13 populations throughout Highlands and Polk counties (Table 1). Most of these populations occur on either public or private conservation lands, with only three populations on private lands with no known conservation mechanism (Table 1). The Archbold Biological Station (ABS) population has many sub-populations that are monitored on a 3-year basis for extant sub-populations and a 6-year basis for extirpated sub-populations. Most of the sub-populations at ABS are small to moderate-sized and are declining due to impacts from prescribed fires over the past few decades (Ward 2021). Sub-population 93 has the highest densities of Florida perforate cladonia at ABS (Table 1), which is largely attributed to lack of fire over the last 34–48 years (Menges et al. 2020).

Staff from ABS also assist in monitoring the populations on FWC's Lake Wales Ridge Wildlife and Environmental Area (LWRWEA), Royce Unit (RU). The RU6 population declined drastically after a prescribed fire in 2014, but RU9 has remained stable (Ward 2021). In RU9, all lichen fragments from 12 long-term monitoring plots were experimentally removed prior to a prescribed fire in 2020, then returned to the monitoring plots after the fire (Menges et al. 2020; Ward 2021). Only 4 of the 19 plots that did not have lichens removed were burned since

most of the interior scrub did not burn, but effects of the fire on the lichens will still be analyzed (Menges et al. 2020; Ward 2021).

The Florida perforate cladonia populations at the Lake Wales Ridge State Forest (LWRSF) are reported as stable to increasing (Rosner-Katz 2019, 2021). These populations are monitored for presence/absence, percent cover, microhabitat, and canopy cover every 3 years, similar to the ABS and LWRWEA populations. The LWRSF populations were last assessed in 2019, and 4 out of the 5 sub-populations increased in occupancy (number of monitoring plots occupied by species), while all 5 sub-populations increased in percent cover within the monitoring plots since the last monitoring event in 2015 (Rosner-Katz 2019). Canopy cover and microhabitat are assessed at these sub-populations to help inform management actions to benefit the lichen. Overall, canopy cover decreased from 2015 to 2019 while litter was the most common microhabitat recorded in 2019 (Rosner-Katz 2019). However, in all 5 sub-populations, Florida perforate cladonia percent cover was higher in plots with bare sand than those with litter, suggesting that management efforts to increase bare sand conditions are needed (Rosner-Katz 2019). While prescribed fire has been applied in the units where the lichen occurs in 2008 and 2015, only a few of the monitoring plots were burned due to the typical patchiness of rosemary scrub fires. However, to prevent another extirpation of a sub-population or population on LWRSF (sub-population LA05 was extirpated during a prescribed fire in 2005 that was hotter than expected due to increased fuel loads from the 2004 hurricanes; Clanton 2007; Rosner-Katz 2021), Rosner-Katz (2019) recommends temporarily removing lichens prior to any prescribed fires, but especially when fuel loads are high.

During the 2020 statewide survey, which included surveys for Florida perforate cladonia at several undocumented sites with suitable habitat, two new populations were reported at the southern end of the Lake Wales Ridge metapopulation, on the Fisheating Creek/Smoak Groves Conservation Easement (Herring 2021). Two other new populations (Lake Wales Ridge National Wildlife Refuge Lake McLeod Unit [van den Ende 2021] and Sun Ray [Navarra 2011]) were discovered since the previous status review (Service 2007), which expand the range of the Lake Wales Ridge metapopulation by approximately 23 miles (37 km) north.

Atlantic Coastal Ridge

Florida perforate cladonia was first discovered in Martin County in 1993 (Service 1993). The Atlantic Coastal Ridge metapopulation currently consists of 14 populations in St. Lucie, Martin, and Palm Beach counties (Table 1). Nine of these populations exist entirely on public or private conservation land, two are entirely on private lands with no conservation mechanism, and three have sub-populations that occur on both. Most of the populations and sub-populations on public or private conservation lands are known or estimated to be stable or increasing, while those on private lands with no conservation mechanism are unknown or declining due to development, ATV use, trash dumping, and lack of habitat management (Black Finch 2021; DeBolt 2021; Herring 2021; Moore

2021; Rossmanith 2021). Since the previous status review (Service 2007), one population and three sub-populations have been extirpated due to development and inadequate habitat management; one population and one sub-population have been introduced; and several populations and sub-populations have been recently discovered (Table 1).

Most of the Atlantic Coastal Ridge metapopulation is centered in southern Martin and northern Palm Beach counties, between Hobe Sound and Jupiter. The Arbors Village Preserve is reported to have more than 100,000 Florida perforate cladonia thalli and is estimated to be stable due to active management of the site (Herring 2021). Jonathon Dickinson State Park (JDSP) has several small populations, some of which have received transplants from nearby private sites in danger of development (Table 1; Richardson and Moore 2011). The Jupiter Inlet Lighthouse Outstanding Natural Area supports two sub-populations, one of which was introduced with transplants from the other (Table 1; DeBolt 2021). Both sub-populations are increasing, and the Bureau of Land Management plans to create more sub-populations with transplants from Lot 19 and the Arbors Village Preserve to increase the species presence on the site, improve genetic diversity, and buffer against catastrophic events (Bureau of Land Management 2021). The Jupiter Ridge Natural Area is another large, stable population with over 100,000 thalli (Black Finch 2021; Herring 2021).

Richardson and Moore (2009, 2011) surveyed over 50 sites in Indian River, St. Lucie, Martin and Palm Beach counties for Florida perforate cladonia presence. The lichen was documented at 21 sites (several of which were previously undocumented) in Martin and Palm Beach counties during these surveys. Additionally, a population was established at Harbor Branch Oceanographic Institute in St. Lucie County during a dispersal study and rescue effort from the right-of-way between the Pine School and U.S. Highway 1 (Richardson and Moore 2011). This population started with less than 200 thalli and has increased to more than 2,000 based on a 2019 estimate (Moore 2021). The Harbor Branch Oceanographic Institute population and the two newly documented populations in northern Martin County (Green River Parkway and Florida Inland Navigation District O-23) expand the range of the Atlantic Coastal Ridge metapopulation by approximately 32 miles (51 km).

c. Genetics:

No new genetic information has become available for Florida perforate cladonia since the previous status review (Service 2007). The previous status review (Service 2007) describes genetic studies conducted in 2000 and 2005 across the three known metapopulations at the time (North Gulf Coast, Lake Wales Ridge, and Atlantic Coastal Ridge). Yahr (2004) reported low genetic diversity within populations but significant genetic variation between populations and metapopulations, indicating very little gene flow between populations. The researchers suggested that because each population of this species is predominantly clonal and genetically distinct, variability can only be protected by

protecting multiple, genetically different populations and metapopulations (Yahr 2000a; Yahr 2004; Yahr and DePriest 2005). Additional genetic studies are planned for populations on the Atlantic Coastal Ridge (Moore 2021).

d. Taxonomic classification or changes in nomenclature:
None. The Integrated Taxonomic Information System (2021) indicates that the current standing of the taxonomic status is accepted.

e. Distribution and trends in spatial distribution:
Florida perforate cladonia continues to occur throughout its known range on the Lake Wales Ridge, Atlantic Coastal Ridge, West Coast, and North Gulf Coast (Service 2007). At the time of listing, the lichen was only known to occur in three counties (Highlands, Okaloosa, and Martin) with six populations (Service 1993). Additional surveys increased the range to six counties (Highlands, Polk, Martin, Palm Beach, Manatee, and Okaloosa) with 16 populations at the time of the previous status review (Service 2007). Introductions and additional surveys have increased the range to seven counties, adding St. Lucie, with 35 populations as of 2021 (Table 1). These introduced and newly discovered populations have increased the species' redundancy within its range and expanded the range of the two largest metapopulations (Lake Wales Ridge and Atlantic Coastal Ridge), though populations are still fragmented and experiencing low gene flow and genetic diversity (Yahr 2000a; Yahr 2004).

f. Habitat or ecosystem conditions:
The distribution of habitat (white sand rosemary and sand pine scrub) within Florida perforate cladonia's known range remains fragmented. The scrub ecosystems are considered globally imperiled (FNAI 2010). Extensive land clearing for human population growth, development, and agriculture has altered, degraded, or destroyed millions of acres of this once abundant ecosystem. Many thousands of acres of scrub have been acquired, protected, and managed by Federal, state, and local governments, only a fraction (about 750 acres; FNAI 2021) of which are occupied by Florida perforate cladonia. Scrub habitats require periodic fires to maintain vegetative structure, and increased development makes applying prescribed fire to remaining habitat difficult. Although lichens are killed by fire and recolonize solely via dispersal from unburned sources, Florida perforate cladonia may be somewhat protected from fire when it occurs in bare-sand gaps and between shrubs, which are considered low- or no-fuel sites (Yahr 2000b). However, fire is necessary to maintain the bare-sand gaps where the lichen is more protected and gets full sun for greater photosynthesis (Richardson and Moore 2011).

Significant remaining scrub habitat occurs on private and publicly owned lands that are not dedicated to or managed for conservation. Suitable habitat for Florida perforate cladonia remaining on these lands is decreasing due to development and degradation. The majority (77 percent) of known Florida perforate cladonia populations occur entirely or partially on publicly owned lands that are managed

for conservation (Table 1). The challenge with managing these fragmented preserves is controlling hardwoods, pines, and invasive plants and applying prescribed fire in a manner that does not harm the lichen (see section II.2.a. below).

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

The purpose of a 5-Year Review is to recommend whether a listed taxon continues to warrant protection under the ESA and, if so, whether it should be reclassified (from threatened to endangered or from endangered to threatened). This task requires that the analysis of the threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of ESA protections may shed light on some future activities that constitute threats to the species. However, the analysis under Factor D (Inadequacy of Existing Regulatory Mechanisms) focuses on the adequacy of existing alternative (i.e., non-ESA) mechanisms to address the continuing and foreseeable threats.

a. Present or threatened destruction, modification or curtailment of its habitat or range:

Continued habitat loss, fragmentation, and changes in land use threaten the existence of Florida perforate cladonia. In some instances, where lichens or suitable habitat occurred on private or unprotected sites, development has led to both direct destruction of plants and habitat because of land clearing and indirect extirpation and habitat degradation from lack of management. For example, at least two sub-populations have been extirpated and nine are declining, with the primary cause being habitat alteration, destruction, and degradation on private lands (Herring 2021; Moore 2021). Threats from development and habitat degradation on private sites are expected to continue and increase. Within the seven counties where the lichen occurs (Okaloosa, Manatee, Polk, Highlands, St. Lucie, Martin, and Palm Beach), the human population is predicted to grow an average of 42 percent from 2010 levels by 2070 (Carr and Zwick 2016). The Florida perforate cladonia populations on public and private conservation lands are protected from development, but those that occur on private lands are vulnerable to habitat loss from development. As scrub habitats become increasingly fragmented and isolated by development, recovery of small, isolated populations following natural disturbances may be more unlikely since larger breaks in suitable habitat exist, making recolonization through natural dispersal more difficult or impossible (Yahr 1997).

Even though the populations of Florida perforate cladonia on public and private conservation lands are not at risk of being developed, the lichens on these sites may still be vulnerable to lack of or improper habitat management. One of the primary threats to scrub is habitat modification and degradation through inadequate fire management, which includes both the lack of prescribed fire and suppression of natural fires. Historically, periodic (5 to 40 years), lightning-induced fires were a vital component in maintaining native vegetation and

ecosystem functioning within this habitat (FNAI 2010). Without fire, successional climax from scrub to xeric hammock takes 50 to 70 years, and displacement of native species by invasive nonnative plants often occurs (FNAI 2010). Although the majority of Florida perforate cladonia populations occur on public and private conservation lands with active habitat management programs, the ability to apply prescribed fire is limited by surrounding development, weather, and staffing. Also, since fire kills lichens, specific management actions (e.g., clearing leaf litter away from lichen clumps, creating more burn units for small, patchy fires, temporarily removing lichens from burn units, etc.) may be needed prior to burns to prevent killing entire populations or sub-populations (Yahr 2000b; Rosner-Katz 2019, 2021; Menges et al. 2020; Ward 2021).

b. Overutilization for commercial, recreational, scientific, or educational purposes:
This was not identified as a potential threat in the original listing rule (Service 1993), the recovery plan (Service 1999, 2019), or the previous 5-year review (Service 2007) and is not known to be a current threat.

c. Disease or predation:
This was not identified as a potential threat in the original listing rule (Service 1993), the recovery plan (Service 1999, 2019), or the previous 5-year review (Service 2007) and is not known to be a current threat.

d. Inadequacy of existing regulatory mechanisms:
Even though lichens are not plants, since they are classified under the kingdom Fungi, Florida perforate cladonia is listed with one other lichen under the ESA as a non-flowering plant, and therefore receives the same protections as plants under the ESA. The ESA prohibits the removal of federally listed threatened and endangered plants or the malicious damage of such plants on areas under federal jurisdiction, or the destruction of endangered plants on non-federal areas in violation of state law or regulations or in the course of any violation of a state criminal trespass law. The ESA does not provide protection for plants on non-federal lands unless it is in violation of state law.

Florida perforate cladonia is also listed by the Florida Department of Agriculture and Consumer Services (FDACS) as State-endangered (5B-40.0055 Regulated Plant Index). Listing by the State is not reliant on ESA protections, but the State listing does not provide any direct habitat protection. State regulations require both written permission from the owner or legal representative and a permit issued by FDACS to collect or remove plants listed as endangered on the Florida Regulated Plant Index from any property. Additionally, Title 62D-2.013 of the Florida Administrative Code prohibits the removal, destruction, or damage of plants from Florida Department of Environmental Protection, Division of Recreation and Park properties. This regulation provides protection for the populations that occur on JDSP but does rely on public adherence to the Code since monitoring is limited. County-level protection where Florida perforate

cladonia occurs is limited to surveys for listed plants and coordination with the appropriate agencies for any required permits or consultation.

Existing regulatory mechanisms do not adequately prevent the development of sites, as several properties with Florida perforate cladonia on private lands have been developed, and the only option for the lichens was to translocate them prior to clearing. Rescue efforts can only take place if the Service or another qualified organization is made aware of impending development. However, as a conservation measure under an ESA section 7 consultation for the construction of an intracoastal waterway dredged material management area on the Florida Inland Navigation District O-23 site, Florida perforate cladonia thalli were relocated from the construction footprint to a preserve area designated on site and a Preserve Area Maintenance and Monitoring Plan will be developed (U.S. Army Corps of Engineers 2020; Herring 2021). Without ESA protections, there would have been limited incentive to protect these lichens.

Because this species occurs in scrub habitat on Florida's coasts and ridges, which is desirable for development and other uses due to its elevation, it remains vulnerable to development pressures where it occurs on private property. Where the species occurs on public land, there is protection from development but not necessarily from habitat degradation. In conclusion, there are no existing regulatory measures that reduce or remove the threat or loss of populations or removal/destruction of plants on private property, and it has only limited protections if the species was not protected under the auspices of the ESA; therefore, existing regulatory mechanisms are inadequate to protect this species.

e. Other natural or manmade factors affecting its continued existence: Florida perforate cladonia continues to be threatened by numerous natural and anthropogenic factors, including intrinsic factors (limited dispersal, slow growth rates, low genetic diversity, population fluctuations, restricted range), stochastic events (hurricanes, droughts, wildfires), climate change, pollution, and human disturbances. The previous status review describes how intrinsic factors of the lichen's life history act synergistically with habitat fragmentation to threaten populations as well as the potential threat of air pollution (Service 2007). Human disturbances, including ATV use, trash dumping, and inadvertent trampling continue to threaten the species, but are mostly restricted to private sites with no conservation mechanism (Herring 2021; Moore 2021).

Climate change presents a variety of threats to the Florida perforate cladonia and its habitat. While the strong influence of ocean currents makes projecting regional climate in Florida difficult (Kirtman et al. 2017), estimates project that Florida's average annual temperatures will increase approximately 1.5–5.5 degrees Fahrenheit (˚F) (0.8–3.1 degrees Celsius [˚C]) by 2050 and from 2.0–11.5°F (1.1–6.4°C) by 2100, depending on the greenhouse gas emission rates and the region in Florida (Runkle et al. 2017). In addition, it is predicted that Florida will experience drier wet seasons and wetter dry seasons (Sun et al. 2015). Higher

temperatures and changes in precipitation patterns could alter relative humidity levels and evapotranspiration rates, leading to the potential for more frequent and intense droughts and wildfire events. These changes would negatively impact Florida perforate cladonia since thalli dry out as air temperatures increase, even on humid days, which makes them brittle and more susceptible to damage (Richardson and Moore 2011). Impacts to photosynthesis and growth rates would also be expected since lichens need water to photosynthesize (Peet and Adams 1972; Kranner et al. 2008), and the lowest growth rates have been documented in the driest months (Richardson and Moore 2011).

The species' restriction to specialized habitat, its limited distribution, and its limited reproductive capacity also render it vulnerable to random natural events, such as wildfires and hurricanes, which are expected to be intensified by climate change. As previously discussed, fire kills lichens, so more frequent and intense wildfires could extirpate populations on both managed lands and private lands with no conservation mechanism. Hurricane frequency, as well as rainfall and intensity, has been increasing since 1970, and will continue to increase as the climate warms (U.S. Global Change Research Program 2018). Hurricanes are a major threat, causing overwash at waterfront populations, windthrow into unsuitable habitat, burial by storm debris, and increased fuels loads from downed vegetation (Yahr 2003; Eglin AFB 2006; Clanton 2007).

Sea-level rise (SLR) is another anticipated consequence of climate change in Florida. A recent acceleration in SLR suggests that over the next century, sea levels are more likely to rise at the medium to extreme-high SLR scenarios (1.0–2.5 meters [3.3–8.2 feet]) than the low to intermediate-low scenarios (0.3–0.5 meters [1.0–1.6 feet]) (Sweet et al. 2017). Under this assumption, low-lying and waterfront areas supporting Florida perforate cladonia (Santa Rosa Island on the North Gulf Coast and several sites on the Atlantic Coastal Ridge) will likely become completely or partially inundated by 2100 and experience impacts from high tide coastal flooding and saltwater intrusion sooner. Florida perforate cladonia populations and habitat at higher elevations and further inland along the Atlantic Coastal Ridge, Lake Wales Ridge, and West Coast will be spared from the direct impacts of SLR that are anticipated for lower elevation areas. However, as sea level rises, development is likely to move to higher elevations, further increasing the threat of development for unprotected populations and habitat.

D. Synthesis

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).

Where habitat remains intact, Florida perforate cladonia depends upon active management to persist. Land management practices, including reduction of hardwoods, creation of sandy openings, targeted prescribed fire, and removal of invasive species, are important for maintaining the habitat needed for this lichen. Existing regulatory mechanisms are inadequate to protect the species on private lands. Habitat loss, fragmentation, and changes in land use continue, and conversion of scrub habitat to urban use along throughout Florida is projected to continue over the next 50 years. The species' restriction to specialized habitat, limited distribution, and small, isolated populations also renders it vulnerable to climate change and random natural events, such as fires and hurricanes. Due to the above ongoing threats, documented declining and unknown population sizes, and unknown population trends (due to no demographic data available for recruitment or size classes), this species continues to meet the definition of endangered under the ESA.

III. RESULTS

A. Recommended Classification:

__X_ **No change is needed**

IV. 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.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF Florida perforate cladonia (*Cladonia perforate*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X__ No change is needed

Review Conducted By: Heather Hitt, Florida Ecological Services Field Office, Vero Beach

FIELD OFFICE APPROVAL:

Field Supervisor, Florida Ecological Services Field Office, Fish and Wildlife Service

Approve LOURDES MENA Digitally signed by LOURDES MENA Date: 2021.08.27 14:31:16 -04'00' Date 8/27/2021

* Since 2014, South Atlantic–Gulf Region Field Supervisors have been delegated authority to approve 5-year reviews that do not recommend a status change.