Florida Bristle Fern
(*Trichomanes punctatum* ssp. *floridanum*)

5-Year Review:
Summary and Evaluation

Photo by Lindsey Riibe, contractor for Fairchild Tropical Botanic Gardens

June 2023

U.S. Fish and Wildlife Service
Southeast Region
Florida Ecological Services Field Office
Vero Beach, Florida

5-YEAR REVIEW
Florida bristle fern (*Trichomanes punctatum* ssp. *floridanum*)

GENERAL INFORMATION

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 history, genetics, and habitats of and threats to this subspecies. We announced initiation of this review and requested information in a published Federal Register notice with a 60-day comment period in 2021 (86 FR 37178; U.S. Fish and Wildlife Service [Service] 2021). We received one public comment during the open comment period that expressed concern for the subspecies and the general threats of climate change and pollution, but no specific information was supplied with the comment. The comment was incorporated into the 5-year review, as appropriate. 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 subspecies. Specific sources included: the final rule (80 FR 60440; Service 2015) listing this plant under the Endangered Species Act of 1973, as amended (Act), peer reviewed scientific publications, and unpublished field observations by state, county, and other experienced biologists. The Service contracted this review to Fairchild Tropical Botanic Gardens (Fairchild) botanists, and it was finalized by the lead recovery biologist for the Florida bristle fern in the Florida Ecological Services Field Office (FESFO), Vero Beach. Literature and documents used for this 5-year review are on file at the FESFO. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on the Florida bristle fern.

Reviewers

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Background

Federal Register Notice citation announcing initiation of this review:
July 14, 2021, 86 FR 37178 (Service 2021)

Listing history
Original Listing
Federal Register Notice: 80 FR 60440 (Service 2015)
Federal Register Notice date: October 6, 2015

Effective listing date: November 5, 2015
Entity listed: *Trichomanes punctatum* ssp. *floridanum*
Classification: Endangered

Associated rulemakings

Final critical habitat designation, 87 FR 78582 (Service 2022). The final critical habitat rule became effective on January 23, 2023.

Review History

This is the first status review for the Florida bristle fern.

Species' Recovery Priority Number at start of review: 6

Degree of Threat: High
Recovery Potential: Low
Taxonomy: Subspecies

Recovery Plan

There is currently no approved recovery plan for the Florida bristle fern, but there is a recovery outline which offers a preliminary course of action for the subspecies until a comprehensive recovery plan can be approved (Service 2018).

REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species as including 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 plant, the DPS policy is not applicable.

Updated Information and Current Species Status

Information on the subspecies' biology and status is thoroughly reviewed in the proposed and final listing rules (79 FR 61136 and 80 FR 60440; Service 2014 and Service 2015). The summary below is based on these documents and available new information.

Biology and Habitat

Summary of new information of species biology and life history

The Florida bristle fern is a minute and inconspicuous, mat-forming plant resembling bryophytes more than what is typical of ferns (Nelson 2000). The fronds (fern leaf) of this subspecies emerge in clusters scattered along long-creeping rhizomes (horizontal stems) and lack a cuticle (waxy protective layer of the leaf which reduces water loss) making them susceptible to desiccation and therefore dependent on elevated moisture conditions (Krömer and Kessler 2006). Endemic to the state of Florida, Florida bristle fern is limited to microhabitats that are protected from extreme fluctuations in temperature and humidity (van der Heiden and Johnson 2014). Extant populations of

Florida bristle fern occur on the walls of limestone solution holes in rockland hammocks in Miami-Dade County and on the vertical faces of limestone boulders in mesic hammocks in Sumter County. Small patches of the subspecies have also been observed on tree trunks near exposed limestone.

Like all ferns, Florida bristle fern has two independent life stages: a gametophyte stage in which sperm and egg are produced for sexual reproduction, and a sporophyte stage which produces and disperses spores (these germinate and become the next generation of gametophytes). The two life stages can have different physiological and ecological requirements (Ranker and Haufler 2008; Nitta et al. 2021). The tiny and cryptic nature of the gametophyte stage makes identification and field observation nearly impossible (Nelson 2000; Service 2015). As such, all vouchers and reported field observations of Florida bristle fern have been of the sporophyte stage.

Mature sporophytes are likely fertile all year in ideal (moist, shaded, protected) conditions, though during the dry season, desiccation of the sporophytes has been observed, and they likely do not produce spores during this time; development of sporangia (structures that house the spores) most likely peaks during the wet season (Possley 2013).

The spores of Florida bristle fern are chlorophyllous (contain chlorophyll), a trait which generally limits desiccation tolerance and therefore longevity (Lloyd and Klekowski 1970; Mellado-Mansilla et al. 2021). Stokey (1940) observed spores of some species of *Trichomanes* (and others in the Hymenophyllaceae) germinating within the sporangia. Recent observations of Florida bristle fern (fertile material collected in 2022) seem to display a similar habit, with what appears to be gametophyte prothalli (green "leaf-like" tissue of the gametophyte life stage) growing on sporangia that are still attached to the soral involucre (funnel-shaped cups where sporangia are produced) (Possley and Riibe 2022). Conservation botanists have had limited success collecting mature spores in the field, with very few spores being released despite the presence of mature sporangia protruding from the soral involucres at the time of collection (Maschinski et al. 2014; Pence 2022). Similarly, attempts to grow Florida bristle fern from spore have had limited success with few of the gametophytes developing sporophytes, none of which survived to maturity (Pence 2014).

Florida bristle fern can also reproduce asexually, producing clones of the parent plant when fragments of the rhizome break off and establish new individuals. In this way, ex-situ collections of Florida bristle fern have been established at Fairchild and by in-vitro cryopreservation (vegetatively propagated clones grown in sterile culture and placed in liquid nitrogen at -196 degrees Celsius for long-term storage) at the Lindner Center for Research on Endangered Wildlife (CREW) at the Cincinnati Zoo and Botanical Garden. Ex-situ conservation of Florida bristle fern is discussed further below.

Abundance, population trends, demography

At the time of listing (2015) there were two known metapopulations (groups of geographically separated populations) of Florida bristle fern, one in Miami-Dade County

and the other approximately 400 kilometers (km) (249 miles [mi]) north-northwest in Sumter County. Both currently still exist and there are a total of six known extant populations (four in Miami-Dade County and two in Sumter County; Table 1). Due to the fern's small size and rhizomatous, mat-forming growth habit, it is nearly impossible to count individual plants. For this reason, populations and sub-populations are typically quantified by the total area covered by each patch or cluster. The six known extant populations cover a total area of approximately 12 square meters (m^2) (129 square feet [ft^2]) (Table 2).

Miami-Dade County metapopulation:
The Miami-Dade metapopulation contains four extant populations, all of which occur, at least partly, within County protected areas managed by the Environmentally Endangered Lands (EEL) program. One of these populations also occurs on private property adjacent to an EEL property (Hattie Bauer Hammock, Table 1). The Miami-Dade populations occur in separate habitat islands (described in Habitat or ecosystem conditions, below), as the surrounding landscape is dominated by residential and agricultural developments that no longer support the rockland hammock habitat where Florida bristle fern grows. For the purposes of this review, the Miami-Dade populations are further divided into subpopulations, corresponding to the individual solution holes in which the subspecies occurs.

Quantitative monitoring of all known Miami-Dade Florida bristle fern populations was conducted by Fairchild biologists in 2013, 2018, and 2021 (Lange et al. 2019; Possley and Riibe 2022). Surveys of the Miami-Dade metapopulation in 2013 measured a combined total area of approximately 9.9 m^2 (107 ft^2) (Table 2). By 2018, the combined total area covered was reduced to 1.22 m^2 (13 ft^2), a loss of 8.69 m^2 (94 ft^2), or approximately 88 percent of the metapopulation, in five years. One factor in the decline was Hurricane Irma, which passed through Miami-Dade County in September 2017, causing treefalls and defoliation that resulted in sudden increases in light levels and a corresponding decrease in humidity in Florida bristle fern habitat. Populations at Castellow Hammock and Hattie Bauer Hammock were noted to be especially affected (Possley 2019).

While all the Miami-Dade populations fluctuated between monitoring periods, Castellow Hammock (previously the largest of the four populations) suffered the greatest loss in area (-8.29 m^2 [-89 ft^2] since 2013). Prior to Hurricane Irma, invasive species management at Castellow Hammock in 2014 resulted in large canopy openings near the bristle fern populations which contributed to a rapid decline in occupied area (Lange et al. 2019). However, an increase in bryophyte density was also observed with the increased light levels, and Fairchild botanists reported Florida bristle fern growing underneath the bryophyte mats (particularly the leafy liverwort, *Neckeropsis undulata*). This suggests that the subspecies persists and may recover with increased canopy cover and that recent (2018-2021) measurements were likely underestimates of total area covered (Lange et al. 2019) due to the difficulty in seeing the fern under the bryophyte mats.

The Meissner Hammock population, which was small in 2013 (0.8 m^2 [8.6 ft^2]) was reduced to just one-third that area by 2021 (0.28 m^2 [3 ft^2]). The reason behind the decline of this population may be due to black vultures (*Coragyps atratus*) using the immediate area as a winter roosting site. Florida bristle ferns that were positioned directly beneath the center of the roost have been observed to be coated in excrement during winter months, following by a die-back in the colony (Possley 2022a).

The Fuchs and Hattie Bauer Hammock populations of Florida bristle fern increased in area from 2018 to 2021 (Table 2). The increase at Fuchs Hammock was slight and is indicative of minor expansion. In contrast, the increase reported at Hattie Bauer Hammock was due to discovery of several new subpopulations extending beyond the previously surveyed area. Two of the newly discovered subpopulations were found within the County preserve, while the majority (12 of 14) of the new subpopulations were found on private property immediately east of Hattie Bauer Hammock EEL Preserve. The first survey of this private property for Florida bristle fern was conducted by Fairchild and Miami-Dade County botanists in February 2022. With these new discoveries, the Hattie Bauer Hammock population of Florida bristle fern is estimated to cover approximately 1.47 m^2 (15.8 ft^2), an increase of more than 1,700 percent. Hattie Bauer Hammock, previously considered the smallest population of Florida bristle fern, is now one of the largest of the Miami-Dade metapopulation, second only to Castellow Hammock (Table 2).

Sumter County metapopulation:
The Sumter metapopulation contains two known populations, both of which occur within the Jumper Creek Tract of Withlacoochee State Forest (Table 1). The Sumter populations occupy limestone boulder fields within mesic hammocks. Like the Miami-Dade populations, the Sumter County populations occur in mesic hammocks that are essentially higher-elevation habitat islands, which rarely flood, and are surrounded by hydric hammock and mixed hardwood wetlands. Unlike the Miami-Dade populations, the two Sumter populations have not been further divided into subpopulations. The occupied boulder fields are generally clustered together with Florida bristle fern sometimes forming a single mat over several rocks and lack obvious separation between patches of the subspecies, whereas the occupied sink holes in Miami-Dade form well defined boundaries for delineating subpopulations.

Currently, the Sumter metapopulation consists of two known extant populations: Rocky Hammock and Tree Frog Hammock, both of which are located within the Jumper Creek Tract of Withlacoochee State Forest (Table 1). Two additional populations were known from private property just south of the state forest, but both were extirpated due to land clearing for agriculture (Service 2015). No additional populations were located during surveys for potential Florida bristle fern habitat throughout much of the Jumper Creek Tract of Withlacoochee State Forest in 2014 and 2015 (van der Heiden 2016).

Qualitative monitoring of the two known extant populations in Sumter County has been done by the Withlacoochee State Forest biologist at least once a year since 2015 to assess threats and manage invasive exotic species (Werner 2022a). Quantitative monitoring of

the two Sumter populations by researchers at Florida Atlantic University in 2014 measured a combined total area of approximately 4.5 m^2 (48 ft^2) (van der Heiden and Johnson 2014). The two populations were measured again in November 2021 and January 2022 by botanists from Fairchild, Selby Botanic Garden, Withlacoochee State Forest, and University of Florida following the methods of van der Heiden and Johnson (2014). The combined total area covered by the Sumter populations in 2021 was estimated to be 8.12 m^2 (87 ft^2), an increase of 3.36 m^2 (36 ft^2) in less than ten years (Possley and Riibe 2022) (Table 2).

TABLE 1. Summary of metapopulations, extant occurrences, and ex-situ collections of Florida bristle fern (Service 2015; Possley and Riibe 2022; Werner 2022a).

Metapopulation*	Population*	Year first reported	Land ownership	Current Number of subpopulations	Ex situ collections
Miami-Dade	Castellow Hammock Park	1903	County	2-3**	Fairchild, Lindner Center for Research on Endangered Wildlife
Miami-Dade	Fuchs Hammock Preserve	1915	County	3-4**	none
Miami-Dade	Hattie Bauer Hammock, including adjacent private parcel	1915***	County & Private	15	none
Miami-Dade	Meissner Hammock	1983	County	2	none
Sumter	Rocky Hammock	2007	State	NA	Fairchild
Sumter	Tree Frog Hammock	2013	State	NA	none

*Current metapopulations and extant populations are the same as at the time of listing (Service 2015).

**Number of subpopulations (occupied solution holes) in a population can vary between years.

***Hattie Bauer Hammock was presumed extirpated until 2011 and occurrence of subpopulations on adjacent private property was not discovered until 2022.

TABLE 2. A summary of estimated size of populations (total area covered), of Florida bristle fern since 2013 and change in size and contributions (percent) of each population (van der Heiden and Johnson 2014; Possley and Riibe 2022). Change in area is the difference in the fern's area covered between the first survey (2013 for Miami-Dade, 2014 for Sumter) and the 2021-2022 surveys; negative values indicate a decrease in area covered, positive values indicate an increase in area covered over time. Percent of whole is the area covered for each population divided by the total area covered by subspecies in 2021-2022.

Meta-population*	**Population**	**Owner**	**Area covered (m^2) 2013-2014**	**Area covered (m^2) 2018**	**Area covered (m^2) 2021-2022**	**Change in area (m^2) 2013-2022**	**Percent of whole subspecies 2022**
Miami-Dade	Castellow Hammock	County	8.75	0.79	1.88	-6.87	16%
Miami-Dade	Hattie Bauer Hammock	County	0.08	0.05	0.17	NA**	12%
Miami-Dade	Hattie Bauer Hammock	Private	NA	NA	1.30	NA**	Totaled above with County Ownership
Miami-Dade	Meissner Hammock	County	0.86	0.31	0.28	-0.58	2%
Miami-Dade	Fuchs Hammock	County	0.22	0.07	0.19	-0.03	2%
Total for Miami-Dade			9.91	1.22	3.82	-7.48	32%
Sumter	Rocky Hammock	State	4.36	NA	7.66	+3.30	64%
Sumter	Tree Frog Hammock	State	0.13	NA	0.46	+0.33	4%
Total for Sumter			4.49	NA	8.12	+3.63	68%
Subspecies Total			**14.40**	**NA**	**11.94**	**-3.85**	

*Miami-Dade populations were surveyed in 2013, 2018, and 2021; Sumter populations were surveyed in 2014 and 2021-2022.

**Change in area is not calculated for Hattie Bauer Hammock because new subpopulations (i.e., occupied holes) were discovered in 2021-2022 that have no past comparison data.

Genetics

A study to determine the genetic diversity among and between the metapopulations of Florida bristle fern is currently under way (Possley and Riibe 2022).

Taxonomic classification or changes in nomenclature

Following the taxonomic revision of the family Hymenophyllaceae by Ebihara et al. (2006), *Didymoglossum* has routinely been accepted as a genus, rather than a section of *Trichomanes* (a section is a taxonomic rank below the genus level but above species).

The Florida bristle fern is one of four subspecies (taxonomic rank below species level) of *Didymoglossum punctatum.* Prior to listing, the species had been transferred to the genus *Didymoglossum* (Ebihara et al. 2006), but new combinations for the subspecies had not yet been published (Service 2015; Weakley et al. 2017). The name *Didymoglossum punctatum* (Poir.) Desv. is currently the accepted name at the taxonomic rank of species (Pteridophyte Phylogeny Group I 2016; Weakley et al. 2017), and new combinations for the other subspecies (*D. punctatum* ssp. *labiatum*; *D. punctatum* ssp. *sphenoides*) were published in 2016 (Boudrie and Cremers 2016).

The name *Didymoglossum punctatum* ssp. *floridanum* is accepted and used by the International Plant Names Index (2022), Flora of the Southeastern United States (Weakley 2022), Institute for Regional Conservation's Floristic Inventory of South Florida (Gann et al. 2001-2022), Tropicos (Tropicos.org 2023), and the Integrated Taxonomic Information System (ITIS; 2023) for Florida bristle fern. However, entities including NatureServe (2022), Flora of North America (1993+), the Florida Plant Atlas (Wunderlin et al. 2022), and World Flora Online (2022) continue to use *Trichomanes punctatum* ssp. *floridanum*. The Plants of the World Online (2023), which publishes taxonomic names accepted by the International Code Nomenclature for algae, fungi, and plants (Turland et al. 2018), also uses *Trichomanes punctatum* ssp. *floridanum* but states that an alternate taxonomy has been proposed as *Didymoglossum punctatum* ssp. *floridanum*. Despite a lag in some of the taxonomic authorities in accepting or publishing the change, the scientific community has accepted and used the name *Didymoglossum punctatum* ssp. *floridanum* for many years.

The Service recognizes this change in taxonomy, however, until we finalize a technical correction of the name, we will continue to reference the species using the name as it was listed under the Act, i.e., *Trichomanes punctatum* ssp. *floridanum*. This updated nomenclature does not impact our assessment of the listed entity (e.g., does not change its distribution, biology, life history or threats), and it is still considered a valid entity by the Service.

Distribution and trends in spatial distribution

The historical range of Florida bristle fern included southern (records from Miami-Dade County and Everglades National Park) and central (Sumter County) Florida.

Miami-Dade County:

The subspecies was first documented in Miami-Dade County by J.K. Small in 1901. This first collection was from Deering-Snapper Creek Hammock, in or near present-day R. Hardy Matheson EEL Preserve, Montgomery Botanical Center, and Smathers Four Fillies Farm. The subspecies has not been recorded in this hammock since its first collection and is considered to be extirpated there (Table 3). Historically, the Miami-Dade metapopulation occupied up to 13 hammocks (11 confirmed and 2 unconfirmed) including at least one site in Everglades National Park (Table 3). Five of the historical records for Florida bristle fern in Miami-Dade County are from hammocks that have since been partly or completely destroyed due to extensive terrestrial and hydrological modifications, such as the construction of Snapper Creek Canal (Service 2015). The

proposed and final listing rules include detailed location descriptions of all known historical and extirpated populations (Service 2014 and 2015). At the time of listing (2015), the known range of Florida bristle fern in Miami-Dade had been reduced to four hammocks (Hattie Bauer Hammock, Fuchs Hammock, Meissner Hammock, and Castellow Hammock).

Sumter County:
Florida bristle fern was first documented in Sumter County by R.P. St. John in 1936. Early collections and herbarium label data for Florida bristle fern collections from this area have imprecise location descriptions making it difficult to know the exact extent of the historical range for this metapopulation, though it is likely to have included at least four separate populations (Table 3); and it may have extended beyond Sumter County into other neighboring counties where potential suitable habitat has since been identified (Service 2015, 2020).

Conversion of mesic hammock to pasture for grazing led to the extirpation of at least two historical populations of Florida bristle fern, one as recently as 2004 (Service 2015; Werner 2022b). No new Sumter County populations have been documented since the subspecies was listed.

TABLE 3. Summary of Historical and Extirpated Occurrences of Florida Bristle Fern (Service 2015, data from Table 1 and Table 2; Werner 2022b).

Meta-population	Population location	Year first reported	Year last reported	Current population status	Current hammock status
Miami-Dade	Snapper Creek Hammock (now R. Hardy Matheson Preserve and Smathers' Four Fillies Farm)	1901	1915	Extirpated	Protected Area, Partially Destroyed
Miami-Dade	Silver Palm Hammock	1903	1903	Extirpated	Protected Area, Hammock Preserved
Miami-Dade	Ross Hammock	1906	1906	Extirpated	Protected Area, Partially Destroyed
Miami-Dade	Royal Palm Hammock (Everglades National Park) aka Paradise Key	1909	1915	Extirpated	Protected Area, Hammock Preserved
Miami-Dade	Shields Hammock	1915	1915	Extirpated	Privately Owned, Destroyed
Miami-Dade	Nixon-Lewis Hammock	1915	1915	Extirpated	Privately Owned, Partially Destroyed
Miami-Dade	Deering Estate at Cutler (Addison Hammock)	1916	1916	Unconfirmed[1]	Protected Area, Hammock Preserved
Miami-Dade	Matheson Hammock Park	1940	1940	Unconfirmed[2]	Protected Area, Hammock Preserved

Miami-Dade	Monkey Jungle (Cox Hammock)	1989	1989	Unknown[3]	Privately Owned, Partially Destroyed
Sumter	11.26 km (7 miles) east of Floral City[4]	1936	1936	Presumed Extirpated	Privately Owned, Presumed Destroyed
Sumter	Floral City Area[4]	1939	1939	Unconfirmed[1]	Unknown
Sumter	Southeast of Floral City[4]	1954	1954	Presumed Extirpated	Privately Owned, Presumed Destroyed
Sumter	Floral City, 11.26 km (7 miles) south (Battle Slough)[4]	1959	1959	Unconfirmed[1]	Privately Owned, Unknown
Sumter	East of Withlacoochee River, off Road #48 (Indian Field Ledges)[4]	1963	1963	Extirpated	Protected Area, Hammock Preserved
Sumter	Rocky Point, north of Wahoo	1983	2004[5]	Extirpated	Privately Owned, Destroyed

[1]initial report is questionable; [2]precise location of sample and associated report is questionable; [3]it is not known whether the subspecies still occurs here due to access issues; [4]Sumter County collections and herbarium label data for *Trichomanes punctatum* ssp. *floridanum* are inaccurate in location descriptions; [5]year the hammock was cleared for agricultural use.

Habitat or ecosystem conditions:

A detailed description of the habitat and microclimatic conditions necessary to support Florida bristle fern is available in the final listing rule (Service 2015) and in the final designation of critical habitat for the subspecies (87 FR 78582, Service 2022). Detailed descriptions of the rockland hammock and mesic hammock habitats the Florida bristle fern inhabits can be found in the Florida Natural Areas Inventory (FNAI) Guide to the Natural Communities of Florida (FNAI 2010).

General habitat requirements for Florida bristle fern include exposed limestone (for anchoring and nutrition) and surrounding upland hammock vegetation that provides adequate shade and minimizes drastic changes in humidity and temperature.

In south Florida, Florida bristle fern is limited to rockland hammocks of the Miami Rock Ridge (Service 2020). The hammocks are essentially "islands" of habitat in heavily developed Miami-Dade County. The fern grows on the vertical walls of solution holes which provide the necessary substrate and buffers the fern from sun exposure, drying winds, and extreme fluctuations in temperature. These limestone solution holes often have standing water for part or all of the year and a layer of organic soil at the base, which creates a high-humidity microclimate necessary to support Florida bristle fern (Service 2020).

In central Florida, the subspecies grows in mesic hammock which is surrounded by a matrix of hydric hammock and mixed wetland hardwoods, creating "islands" of Florida bristle fern habitat. Here, the subspecies grows on the vertical face of above-ground limestone boulders in an environment lacking the exposed solution holes found in its southern rockland hammock habitat. The subspecies occurs most often on the north side

of the hammock and on the north side of the boulders (van der Heiden and Johnson 2014).

Although the two regions appear to be quite different topographically and are separated by approximately 400 km (249 mi) geographically, both the Miami-Dade and Sumter County upland hammock forest communities can be characterized by dense canopy cover (above 75 percent canopy closure) and high humidity (above 90 percent relative humidity) (van der Heiden and Johnson 2014; Service 2020). Neither of the hammock environments where the subspecies occurs regularly flood, however, both habitat types depend on intact hydrology and a high water table to maintain consistently high humidity levels (FNAI 2010; Service 2020).

Most extant populations occur within State and County preserves where Florida bristle fern habitat is in good condition. However, most of the privately owned unoccupied hammocks throughout the subspecies' range (especially in south Florida) are degraded or destroyed due to conversion for agriculture and urban or residential development, as well as the introduction of non-native exotic species.

Other

Fairchild, Marie Selby Botanic Garden, and CREW have been working to propagate Florida bristle fern since 2005 (Maschinski et al. 2014; Pence 2014; Gann 2015; Lange et al. 2019). Collecting spores from the tiny plant is challenging and the spores cannot tolerate desiccation (Maschinski et al. 2014; Possley and Riibe 2022). Propagation of Florida bristle fern from spore has had limited success, and currently there are no spore-germinated ex-situ collections of the subspecies (Pence 2022). As mentioned above, the spores of Florida bristle fern are chlorophyllous and may begin to germinate while still within the sporangium (Possley and Riibe 2022). Ex-situ conservation would benefit from additional research including development of best practices for spore collection and propagation.

Vegetative propagation of Florida bristle fern has been far more successful. Currently, there are 20 colonies growing on limestone rocks and pieces of concrete in ex-situ conservation at Fairchild (Possley 2022b). Five of these colonies are from five accessions collected at Rocky Hammock, Sumter County, in 2021, and 15 are from one accession collected at Castellow Hammock, Miami-Dade County, in 2005 (Table 1). There is also one accession in cryopreservation at CREW which was propagated in-vitro from sporophyte material collected in Miami-Dade County (Pence 2022).

Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):
The purpose of a 5-year review is to assess whether a listed taxon continues to warrant protection under the Act and, if so, recommend whether it should be classified (as threatened or endangered). The status of a species is determined from an assessment of the populations and abundance of the species and the factors impacting the species (threats) specified in section 4 (a)(1) of the Act.

Factor A. Present or threatened destruction, modification or curtailment of its habitat or range

Destruction and modification of habitat for agriculture and urban development led to the extirpation of Florida bristle fern from at least six rockland hammocks in south Florida (in Miami-Dade County and Everglades National Park) and at least four locations in Sumter County over the past century. Extirpations have happened as recently as 2004 (Table 3). Although all but a portion of one of the known extant populations of Florida bristle fern are within protected areas (state forest and county preserves, see Table 1), habitat loss, fragmentation, and changes in land use continue to threaten Florida bristle fern and are expected to impact its habitat in the future.

In Miami-Dade County, the rockland hammock habitat upon which Florida bristle fern depends is considered globally and locally imperiled (FNAI 2010). Currently occupied habitat consists of small hammock remnants within a highly fragmented landscape, the extent of which is nearly 80 percent smaller than its historical range (Service 2020). Although the four extant populations in south Florida are mostly within County EEL preserves and are unlikely to be developed directly, development of the surrounding area puts direct pressure on the underlying hydrology of Florida bristle fern habitat, a threat that will likely be exacerbated by climate change and future sea level rise.

The private portion of the Hattie Bauer Hammock population of Florida bristle fern is currently under an EEL covenant, administered by Miami-Dade County. Through this covenant, the property owner has agreed to not develop the land for 10 years, in exchange for a reduction in property taxes. However, there is no obligation to renew the covenant when it expires. County Natural Forest Community (NFC) designation offers some additional protection against development, but development remains possible. For further discussion of regulations pertaining to NFCs in Miami in discussions of Factor D: Inadequacy of existing regulatory mechanisms, below.

Because the two known extant populations in Sumter County occur on state forest land, future development of occupied habitat is unlikely; however, changes in land use on private land adjacent to Jumper Creek Tract of Withlacoochee State Forest (i.e., land clearing and hydrological alterations) is a continuing threat. The mesic hammock habitat has a restricted range and is rare globally and locally (FNAI 2010). Additionally, due to past land clearing for agriculture and historical logging in Sumter County, much of the Florida bristle fern habitat has been modified, even on current conservation lands (Service 2015).

Non-native invasive species threaten Florida bristle fern throughout its range, primarily by occupying potential habitat. The proposed listing (Service 2014) has a complete discussion of impacts to the Florida bristle fern from non-native invasive species, including a list of problematic species. While invasive species management is critical to recovering Florida bristle fern, unintentional consequences from invasive species management activities is also a threat. For example, past management activities at Castellow Hammock Park resulted in opening of the forest canopy, which contributed to a substantial decline in area covered by the subspecies (Lange et al. 2019). Invasive

species management will continue to affect Florida bristle fern habitat in Sumter and Miami-Dade counties.

High humidity and dense canopy cover are critical for the survival of Florida bristle fern, and any changes in ambient humidity levels or canopy cover pose a threat to the subspecies. Forested areas surrounding Florida bristle fern habitat provide a buffer, shielding it from the drying winds and large fluctuations in temperature and humidity experienced near the edge of forested areas (edge effects). Declines in the health of extant populations have been observed during small, seasonal drops in humidity in central Florida (van der Heiden and Johnson 2014) and from new openings in the forest canopy in south Florida (Lange et al. 2019). Therefore, development of areas surrounding protected Florida bristle fern habitat, regardless of habitat suitability for the subspecies, also poses a threat to its habitat and survival.

Factor B: Overutilization for commercial, recreational, scientific, or educational purposes

Overutilization was not identified as a potential threat in the final listing rule (Service 2015) or recovery outline (Service 2018) and there are no known recent or historical human uses of Florida bristle fern.

Factor C: Disease or predation

Disease and predation have not been studied but are not currently considered a threat to Florida bristle fern.

Factor D: Inadequacy of existing regulatory mechanisms

Federal: The Act 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. Therefore, the Act does not provide protection for plants on non-federal lands in Florida unless their removal or damage is in violation of state law (Florida Department of Agriculture and Consumer Services [FDACS] Rule 5B-40). Since the only known extant populations of Florida bristle fern occur on state-, county-, and privately-owned properties, development of these areas is not likely to require a federal permit or other authorization.

State: Florida bristle fern is listed by FDACS as endangered (5B-40.0055 Regulated Plant Index; 2020). Florida Statute 581.185 protects endangered plant species from willful destruction and harvest on both public and private lands. State regulations require both written permission from the owner or their legal representative and a permit issued by FDACS to collect or remove plants or parts of plants listed as endangered on the Florida Regulated Plant Index from any property (Section 3), but these regulations can be waived by private landowners and public agencies for land clearing associated with agriculture, fire control, mining, or construction (Section 8). Listing by the State does not provide any direct habitat protection. Following these protections also require that the plant can be identified, which is a doubtful expectation of the general public.

In central Florida, the two extant Florida bristle fern populations occur within Withlacoochee State Forest and are managed by Florida Forest Service (FFS). Rule 5I-4.005 of the Florida Administrative Code for FFS (2016) prohibits the destruction and removal of soil, rocks, or plants from any managed lands (Section 1) unless a State Forest Use Permit is issued for educational or research purposes (Section 2). The Withlacoochee State Forest Management Plan (FDACS 2015) also prohibits removal of limestone and any plant species from the state forest and aims to minimize foot traffic and airboat landings within rockland hammocks; however, areas where Florida bristle fern habitat occur are monitored infrequently (i.e., annually) making enforcement of these regulations difficult. Furthermore, enforcement is not discussed in the Management Plan.

Miami-Dade County: The entirety of three Miami-Dade Florida bristle fern populations and a portion of the fourth occur in County preserves (Hattie Bauer Hammock, Castellow Hammock Park, Meissner Hammock, and Fuchs Hammock Preserve) and therefore are afforded some protection from development by virtue of being designated preserves in the County's EEL program (EEL 2022).

All Miami-Dade populations of Florida bristle fern occur in areas designated by the County as NFCs. Section 24-49 of the County code provides legal protection for NFC sites by enacting regulations on habitat alterations to minimize damage to and protect environmentally sensitive forest lands. The Miami-Dade County Department of Regulatory and Economic Resources has regulatory authority over NFCs and is charged with enforcing regulations that provide partial protection on the Miami Rock Ridge. Miami-Dade County code typically allows development of 10 percent of hammock properties larger than 5 acres, or development of 0.5 acres for properties less than 5 acres. If the landowner can demonstrate that limiting development to 10 percent does not allow for "reasonable use" of the property, additional development (up to 100 percent of the property) may be approved. NFC landowners are also required to obtain an NFC permit for any work within the boundaries of the NFC property. Section 26-1, Rule 8 of the Miami-Dade County code (2022) requires a special permit to conduct scientific research or collect botanical specimens from any County-owned park or preserve.

Sumter County: Sumter County code prevents destruction of endangered, threatened, and rare species by "major developments" but does not prevent conversion of habitat for agricultural use, nor does it prevent building on sites occupied by endangered plants (Sec. 13-573; 2022). Currently, agriculture and development are encouraged in Sumter County and no regulatory mechanisms exist to protect Florida bristle fern or its habitat on private lands.

In summary, there are no existing mechanisms that adequately reduce or remove the threats to or loss of Florida bristle fern populations or habitat on private property, and there are only limited protections on public land.

Factor E. Other natural or manmade factors affecting its continued existence
Several natural and manmade factors affect the continued existence of Florida bristle fern. A detailed discussion of these factors is available in the final listing rule (80 FR

60440, Service 2015) and in the final designation of critical habitat for the subspecies (87 FR 78582, Service 2022). A summary of these additional threats are provided below. Collectively, these threats have occurred in the past, are impacting the species now, and will continue to impact the species in the future.

The subspecies is immediately vulnerable to extinction because only a few isolated populations remain within a restricted range. The entire biomass of the subspecies covers an area less than 12 m^2 (129 ft^2), spread across six small populations (Table 2). Of these, a single population (Rocky Hammock, Sumter County metapopulation) contributes 64 percent of the subspecies' total area. The loss of a single population could mean a loss of over half of the subspecies' total area or the loss of an entire metapopulation from a single stochastic event. Furthermore, the populations within each of the two metapopulations are close together. For example, Rocky Hammock and Tree Frog Hammock are separated by less than 700 meters (0.4 miles) and Fuchs Hammock and Meissner Hammock are separated by approximately 250 meters (0.15 miles). Environmental stochasticity (e.g., hurricanes, flooding, treefall) in combination with aspects of the subspecies' natural history (e.g., dependence on a high-humidity microclimate) contribute to imperilment through direct mortality.

Other natural and anthropogenic factors are also identifiable threats to Florida bristle fern. In Sumter County, trampling by feral pigs and by livestock from adjacent private property is possible, as is trampling by hunters (temporary blinds and campsites in Rocky Hammock have been observed during monitoring). When water levels are high, airboat landings could impact the subspecies in Sumter County as well, though this has not been documented near occupied hammocks. In Miami-Dade County, impacts by vegetation management crews could threaten the subspecies if too much clearing takes place or plant debris is piled in, on, or around occupied solution holes. Hikers may also cause impacts by scraping the fern off the solution hole walls when climbing in and out. Illegal dumping in EEL Preserves is another possible threat in Miami-Dade County, but this is usually limited to preserve edges, where Florida bristle fern is not found.

Observed climate changes include, but are not limited to, warmer global surface temperatures, increased frequency and intensity of heavy precipitation, global sea level rise, and increased number and intensity of extreme weather events (e.g., droughts, heavy precipitation, tropical cyclones, heat waves) (Intergovernmental Panel on Climate Change 2021). Under simulations for two greenhouse-gas emissions pathways, representative concentration pathways (RCP) of 4.5 (intermediate-high) and 8.5 (extreme), the mean temperature in Miami-Dade County is predicted to increase 2.0-4.0 degrees Fahrenheit (1.1-2.2 degrees Celsius) by 2074 (Alder and Hostetler 2013). Under these same simulations, precipitation is expected to decline 1.0 (RCP 4.5) to 2.0 (RCP 8.5) inches per month (2.5 to 5.1 centimeters per month) throughout the majority of the wet season (May through September) by 2074. Higher temperatures and changes in precipitation patterns could alter relative humidity levels, leading to the potential for more frequent and intense droughts. Florida bristle fern is hygrophilous (living or growing in damp places) and may already be living near its drought threshold for survival in Miami-Dade County.

In addition to changes in precipitation and temperatures patterns, there are also anticipated changes to the severity of tropical storms and hurricanes. Increased rainfall and wind speeds are predicted for storm centers, in part, due to higher sea surface temperatures (Sweet et al. 2018; Runkle et al. 2022). Damage from Hurricane Irma in 2017 contributed to a drastic decline of the Miami-Dade metapopulation, with a combined loss of approximately 88 percent total area covered between 2013-2018 (Possley and Riibe 2022). Damage from future storms could have similar (or potentially greater) impact on the subspecies' habitat.

Sea-level rise (SLR) is another anticipated consequence of climate change in Florida. By 2100, it is predicted that sea levels in south Florida will rise between 2.13 ft (0.64 m) and 7.12 ft (2.17 m) (Sweet et al. 2022). Drainage and construction of canals have caused the water table in south Florida to drop resulting in extensive alteration of the rockland hammock habitat on which Florida bristle fern depends. These rockland hammocks are expected to be further degraded due to SLR, with shifts in vegetation expected across the Miami Rock Ridge as salinity of the water table and soils increases (Service 2020).

Synthesis:

Florida bristle fern is a small and inconspicuous, mat-forming fern restricted to the state of Florida with extant populations persisting in two counties (metapopulations), Miami-Dade in south Florida and Sumter in central Florida. Plants occur in different habitats in the two counties and are separated geographically by a distance of 400 km (249 mi). While all but a portion of one known population occur completely within state forest or county preserves, future development, changes in land use, changes in microhabitat conditions, and human disturbance remain a threat. Fragmentation and extirpations have resulted in low resiliency and reduced representation and redundancy (compared to historical occurrences). Currently, the global distribution of Florida bristle fern covers an area less than 12 m^2 (129 ft^2), distributed across two small metapopulations, making it immediately vulnerable to extinction from stochastic environmental events. Additionally, the existing regulatory mechanisms do not provide adequate protection for the subspecies. Based on the status of the subspecies and the severity of threats it faces, the Florida bristle fern continues to meet the definition of endangered.

RECOMMENDATIONS FOR FUTURE ACTIVITIES

A brief discussion of recovery actions for the Florida bristle fern are presented in the Recovery Outline (Service 2018). During this status review, new and/or targeted potential recovery activities were identified and are included below.

Recovery Activities

- Treat and remove invasive vegetation carefully to prevent large openings in the canopy. Take measures to shade Florida bristle fern populations or clusters (with shade cloth or by planting native trees) if necessary.
- Work with private landowners surrounding occupied hammocks (especially bordering Hattie Bauer Hammock) to treat invasive vegetation and maintain native plant diversity.

- Conduct reintroductions at historically occupied hammocks where habitat remains (see Table 3).

Monitoring/Research Activities

- Conduct surveys for new populations of the Florida bristle fern, specifically in privately-owned hammocks surrounding occupied sites in Miami-Dade County (especially on the eastern border of Hattie Bauer Hammock) and within the Southwest Florida Water Management District's Green Swamp Wilderness Preserve in Sumter and bordering counties.
- Conduct research to develop best practices for spore collection and propagation.

REFERENCES

Alder, J.R. and S.W. Hostetler. 2013. U.S. Geological Survey National Climate Change Viewer: Summary of Miami-Dade County. U.S. Geological Survey https://doi.org/10.5066/F7W9575T.

Boudrie, M. and G. Cremers. 2016. Nomenclatural note on the pteridophyte flora of the Guianas. American Fern Journal, 106(3), 171-174.

Ebihara, A., J.Y. Dubuisson, K. Iwatsuki, S. Hennequin, and M. Ito. 2006. A taxonomic revision of Hymenophyllaceae. Blumea-Biodiversity, Evolution and Biogeography of Plants, 51(2), 221-280.

Environmentally Endangered Lands (EEL) Program of Miami-Dade County, Florida. 2022. https://www.miamidade.gov/environment/endangered-lands.asp. Accessed May 1, 2022.

Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 22+ vols. New York and Oxford. http://beta.floranorthamerica.org. Accessed April 15, 2022.

Florida Department of Agriculture and Consumer Services (FDACS). 2015. Ten Year Resource Management Plan for the Withlacoochee State Forest. Florida Forest Service, Tallahassee, Florida. 81 pp.

Florida Forest Service (FFS). 2016. Rule 5I-4.005 Protection of Managed Lands. Florida Administrative Code. Florida Forest Service, Tallahassee, Florida.

Florida Department of Agriculture and Consumer Services (FDACS). 2020. 5B-40.0055 Florida Regulated Plant Index. Florida Department of Agriculture and Consumer Services, Tallahassee, Florida.

Florida Natural Areas Inventory (FNAI). 2010. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, Florida. 228 pp.

Gann, G.D. 2015. Vascular Plant Species of Management Concern in Everglades National Park. Final Report. The Institute for Regional Conservation. Miami, Florida.

Gann G.D., C.G Stocking, and Collaborators. 2001-2022. Floristic Inventory of South Florida Database Online. The Institute for Regional Conservation. Delray Beach, Florida.

Hughes, C. 2015. DNA sequence analysis of two filmy ferns *Trichomanes punctatum*, populations in Florida. Report. Florida Atlantic University. 2 pp.

Integrated Taxonomic Information System (ITIS). 2023. *Didymoglossum punctatum* (Poir.) Desv.https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=819467#null. Accessed May 26, 2023.

Intergovernmental Panel on Climate Change. 2021. Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. In Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Pean, S Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekci, R. Yu, and B. Zhou (Eds.), Cambridge University Press. In Press.

International Plant Names Index. 2022. Published on the Internet http://www.ipni.org, The Royal Botanic Gardens, Kew, Harvard University Herbaria & Libraries and Australian National Botanic Gardens. Accessed April 15, 2022.

Krömer, T. and Kessler, M. 2006. Filmy ferns (Hymenophyllaceae) as high-canopy epiphytes. Ecotropica, 12, 57-63.

Lange, J., J. Possley, L. Cuni, S. Wintergerst and B. Harding. 2019. Conservation of South Florida Endangered and Threatened Flora: 2018-2019 program at Fairchild Tropical Botanic Garden. Final report for Contract #025243, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, Florida.

Lloyd, R.M. and E.J. Klekowski, Jr. 1970. Spore germination and viability in Pteridophyta: evolutionary significance of chlorophyllous spores. Biotropica, 2(2), 129-137.

Maschinski, J., D. Powell, S. Hodges, J. Possley, S.J. Wright, and V. Pence. 2014. Conservation of South Florida Endangered and Threatened Flora: 2013-2014 Program at Fairchild Tropical Botanic Garden. Final Report Contract #20161. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, Florida.

Mellado-Mansilla, M., G. Zotz, H. Kreft, M. Sundue, and M. Kessler. 2021. The taxonomic distribution of chlorophyllous spores in ferns: An update. American Fern Journal, 111(2), 150-156. https://doi.org/10.1640/0002-8444-111.2.150.

Miami-Dade County, Florida Code of Ordinances. 2022. Sec. 26-1. - Rules and regulations adopted. Online content updated February 14, 2022, https://library.municode.com/fl/miami_-_dade_county/codes/code_of_ordinances. Accessed May 5, 2022.

NatureServe. 2022. NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available https://explorer.natureserve.org/. Accessed April 15, 2022.

Nelson, G. 2000. Ferns of Florida. Pineapple Press, Inc. Sarasota, Florida.

Nitta, J.H., J.E. Watkins, Jr., N.M. Holbrook, T.W. Wang, and C.C. Davis. 2021. Ecophysiological differentiation between life stages in filmy ferns (Hymenophyllaceae). Journal of Plant Research, 134, 971–988. https://doi.org/10.1007/s10265-021-01318-z

Pence, V.C. 2014. In vitro propagation and cryopreservation of the endangered filmy fern, *Trichomanes punctatum* subsp. *floridanum* (Hymenophyllaceae). Fern Gaz, 19(8), 307-317.

Pence, V.C. 2022. Personal Communication. Director of Plant Research, Center for Conservation and Research of Endangered Wildlife (CREW) Cincinnati Zoo and Botanical Garden. Email to Riibe, Fairchild Tropical Botanic Garden, May 4.

Plants of the World Online. 2023. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet; http://www.plantsoftheworldonline.org/ Accessed June 2, 2023.

Pteridophyte Phylogeny Group I. 2016. A community-derived classification for extant lycophytes and ferns. Journal of Systematics and Evolution, 54(6), 563-603.

Possley, J. 2013. Personal Communication. Conservation Program Manager, Fairchild Tropical Botanic Garden. Phone call with U.S. Fish and Wildlife Service, October 23.

Possley, J. 2019. Status update on Miami-Dade County populations of Florida bristle fern, *Trichomanes pucntatum* ssp. *floridanum*. Unpublished report. Fairchild Tropical Botanic Garden, Miami, Florida. April 2019.

Possley, J. 2022a. Status update on Meissner Hammock EEL Preserve population of Florida bristle fern, *Trichomanes punctatum* ssp. *floridanum*. Unpublished report. Fairchild Tropical Botanic Garden, Miami, Florida. June 2022.

Possley, J. 2022b. Personal Communication. Conservation Program Manager, Fairchild Tropical Botanic Garden. Email to Riibe, Fairchild Tropical Botanic Garden, April 27.

Possley, J. and L. Riibe. 2022. Reintroducing endangered Florida bristle fern to appropriate Miami-Dade habitat, Phase I. Interim report to USFWS South Florida Ecological Services Office for Grant No. F21AP033570-00.

Ranker, T.A. and C.H. Haufler, eds. 2008. Biology and evolution of ferns and lycophytes. Cambridge University Press, Cambridge, UK. 480 pp.

Runkle, J., K.E. Kunkel, S. Champion, R. Frankson, B.C. Stewart, W. Sweet, and S. Rayne. 2022: Florida State Climate Summary. NOAA Technical Report NCICS 150-FL, 5 pp.

Stokey, A.G. 1940. Spore germination and vegetative stages of the gametophytes of *Hymenophyllum* and *Trichomanes*. Botanical Gazette, 101(4), 759-790.

Sumter County, Florida Code of Ordinances. 2022. Sec. 13-573. - Flora and fauna. Online content updated March 29, 2022, https://library.municode.com/fl/sumter_county/codes/code_of_ordinances. Accessed May 5, 2022.

Sweet, W.V., G. Dusek, J. Obeysekera, and J. Marra. 2018. Patterns and projections of high tide flooding along the U.S. coastline using a common impact threshold. NOAA Technical Report NOS-CO-OPS 086. February 2018. 56 pp.

Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak. 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf

Tropicos.org. 2023. Missouri Botanical Garden. Tropicos v3.4.1. https://tropicos.org/name/100470866. Accessed June 2, 2023.

Turland, N.J., J.H. Wiersema, F.R. Barrie, W. Greuter, D.L. Hawksworth, P.S. Herendeen, S. Knapp, W.H. Kusber, D.Z. Li, K. Marhold, T.W. May, J. McNeill, A.M. Monro, J. Prado, M.J. Price, and G.F. Smith (eds.) 2018: *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. Regnum Vegetabile 159. Glashütten: Koeltz Botanical Books. DOI https://doi.org/10.12705/Code.2018

U.S. Fish and Wildlife Service (Service). 2014. "Endangered and Threatened Wildlife and Plants; Endangered Species Status for *Trichomanes punctatum* spp. *floridanum* (Florida Bristle Fern); Proposed rule", 79 FR 61136 (October 8, 2014), pp. 61136-61161.

U.S. Fish and Wildlife Service (Service). 2015. "Endangered and Threatened Wildlife and Plants; Endangered Species Status for *Trichomanes punctatum* spp. *floridanum* (Florida Bristle Fern); Final rule", 80 FR 60439 (October 6, 2015), pp. 60440-60465.

U.S. Fish and Wildlife Service (Service). 2018. Recovery Outline for Florida Bristle Fern (*Trichomanes punctatum* ssp. *floridanum*). U.S. Fish and Wildlife Service, Vero Beach, Florida.

U.S. Fish and Wildlife Service (Service). 2021. "Endangered and Threatened Wildlife

and Plants; Initiation of 5-Year Status Reviews for 37 Southeastern Species", 86 FR 37178 (February 24, 2020), pp. 37178-37181.

U.S. Fish and Wildlife Service (Service). 2022. "Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Florida Bristle Fern; Final Rule", 87 FR 78582 (February 24, 2020), pp. 78582-78610.

van der Heiden, C. 2016. Habitat delineation for Florida bristle fern (*Trichomanes punctatum* ssp. *floridanum*) in and around the Jumper Creek Tract of the Withlacoochee State Forest. Final report submitted to the U.S. Fish and Wildlife Service, Vero Beach, Florida. Grant Agreement # F11AP00625, January 19, 2016. 23 pp.

van der Heiden, C. and J. Johnson. 2014. Determining habitat requirements of the rare Florida bristle fern (*Trichomanes punctatum* ssp. *floridanum*). Final report submitted to the U.S. Fish and Wildlife Service, Vero Beach, Florida. Grant Agreement # F11AP00625 January 31, 2014. 33 pp.

Weakley, A.S. 2022. Flora of the southeastern United States. University of North Carolina Herbarium, North Carolina Botanical Garden, Chapel Hill, North Carolina.

Weakley, A.S., D.B Poindexter, R.J. LeBlond, B.A. Sorrie, C.H. Karlsson, P.J. Williams, E.L. Bridges, S.L. Orzell, B.R. Keener, A. Weeks, R.D. Noyes, M. Flores-Cruz, J.T. Diggs, G.D. Gann, and A.J. Floden. 2017. New combinations, rank changes, and nomenclatural and taxonomic comments in the vascular flora of the southeastern United States. II. Journal of the Botanical Research Institute of Texas, 11(2), 291-325.

Werner, C. 2022a. Personal Communication. Biological Scientist II, Withlacoochee State Forest. Email to Riibe, Fairchild Tropical Botanic Garden, April 26.

Werner, C. 2022b. Personal Communication. Biological Scientist II, Withlacoochee State Forest. Email to Riibe, Fairchild Tropical Botanic Garden, May 18.

Wessels Boer, J.G. 1962. The new world species of *Trichomanes* sect. *Didymoglossum* and *Microgonium*. Acta Botanica Neerlandica, 11(3), pp.277-330.

World Flora Online. 2022. *Didymoglossum punctatum* (Poir.) Desv. Published on the Internet http://www.worldfloraonline.org/taxon/wfo-0001108977. Accessed June 2, 2023.

Wunderlin, R.P., B.F. Hansen, A.R. Franck, and F.B. Essig. 2022. Atlas of Florida Plants (http://florida.plantatlas.usf.edu/). [S.M. Landry and K.N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.

RESULTS/SIGNATURES

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Florida Bristle Fern (*Trichomanes punctatum* ssp. *floridanum*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

_____ Downlist to Threatened
_____ Uplist to Endangered
_____ Delist
_X_ No change needed

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

FIELD OFFICE APPROVAL:

Division Manager, Florida Classification and Recovery, Florida Ecological Services Field Office, Fish and Wildlife Service

Approve LOURDES MENA Digitally signed by LOURDES MENA Date: 2023.07.06 12:47:32 -04'00' Adobe Acrobat version: 2023.003.20215

LEAD REGIONAL OFFICE APPROVAL:

***Acting for* Assistant Regional Director – Ecological Services, Fish and Wildlife Service**

Approve AARON VALENTA Digitally signed by AARON VALENTA Date: 2023.07.05 09:36:23 -04'00'