

## SPECIES ACCOUNT: *Asplenium scolopendrium* var. *americanum* (American hart's-tongue fern)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Threatened; 7/14/1989; Northeast Region (R5) (USFWS, 2016)

### **Physical Description**

A perennial fern with evergreen strap-shaped fronds that are 12 to 42 cm long, 2 to 4.5 cm wide, and auriculate at their base. The green petiole is 3 to 12 cm long and has cinnamon-colored scales. The sori (groups of spore-producing reproductive structures called sporangia) are linear in shape and occur on the underside of the blade portion of the frond. The fronds arise in a cluster from a short, creeping rhizome covered with cinnamon-colored scales (USFWS, 1993).

### **Taxonomy**

Aspleniaceae

### **Historical Range**

See current range/distribution.

### **Current Range**

Known from New York, Michigan, Alabama (two counties in each) and Tennessee (one county); and in the province of Ontario, Canada (USFWS, 1993).

### **Critical Habitat Designated**

No;

### ***Life History***

### **Food/Nutrient Resources**

### **Reproductive Strategy**

Adult: Spores (NatureServe, 2015)

### **Reproduction Narrative**

Adult: Briefly, all ferns alternate between haploid generations consisting of spores that grow into the life stage associated with sexual reproduction, the gametophyte, and diploid generations. The sperm and egg join on the gametophyte to form a diploid zygote that grows into the sporophyte life stage, which is familiar to most observers of ferns. Haploid spores are then produced and the life cycle continues (Figure 2-2). A heteromorphic alternation of generations is present in the AHTF, consisting of a tetraploid sporophyte generation (Britton 1953, p. 583) and gametophyte generation that are nutritionally independent of each other. Some evidence has indicated that ploidy level may vary within the hart's-tongue fern (D. Fernando, SUNY-ESF, per. com.). Britton (1953, p. 583) is commonly cited as the source of ploidy differences between the AHTF and the EHTF; however, only two individuals from Ontario, Canada, were utilized in this study (Testo and Watkins 2011, p. 400). (USFWS, 2019)

**Habitat Type**

Adult: Terrestrial (USFWS, 1993)

**Habitat Vegetation or Surface Water Classification**

Adult: Dolomitic limestone outcrops (northern populations); within limestone pits (southern populations) (USFWS, 1993)

**Environmental Specificity**

Adult: Very narrow to narrow (NatureServe, 2015)

**Habitat Narrative**

Adult: This species is found on dolomitic limestone outcrops (northern populations) or within limestone pits (southern populations), in areas of high humidity, shaded conditions, and a moist substrate (USFWS, 1993). It typically occurs in moist crevices, on mossy rock outcrops, or in sinkholes or blowholes of limestone caves. Most populations are associated with cool, well-shaded, moist microclimates; many occur in shady hardwood woodlands where sun flecks provide sufficient sunlight and where moisture is adequate. Most adult plants were found beneath 0-25% herbaceous cover, while most sporelings were found beneath a higher percentage (26- 50%) of herb cover. Few individuals of any life stage were found where herbaceous cover exceeded 75% (NatureServe, 1993).

***Dispersal/Migration*****Dispersal/Migration Narrative**

Adult: Spore dispersal mechanisms in the AHTF have not been well studied; however, it is widely accepted that wind is the primary spore dispersal mechanism for most terrestrial ferns. (USFWS, 2019)

***Population Information and Trends*****Population Trends:**

Decline of <50% to relatively stable (NatureServe, 2015)

**Species Trends:**

Decline of <30% to relatively stable (NatureServe, 2015)

**Resiliency:**

In order to have resilient populations, the AHTF needs sufficiently large populations, with stable or increasing number of individuals (i.e., trend) and all life stages present, and adequate moisture (i.e., cool/moist microclimate, well-drained), substrate (i.e., deciduous canopy, low herbaceous cover), light (i.e., crevices, soil depth, High Mg limestone bedrock), and freeze/thaw buffer (i.e., winter snowpack, geothermal buffering) conditions. Based on over 100 years of survey data for the AHTF in New York, the core team determined that populations greater than 400 individuals are most resilient to stochastic changes in the environment, populations with 100 to 400 individuals are moderately resilient, and populations less than 100 individuals are least resilient. Invasive species compete with the AHTF for available substrate and light resources as well as degrade their quality. (USFWS, 2019)

**Representation:**

For the purposes of this SSA, we determined that the breadth of adaptive capacity can be captured by distribution of populations of AHTF within two representative units (one with two sub-units). We chose these representative units based primarily on the genetic and ecological distinctiveness of the southern populations of AHTF when compared to those in the northern portion of the range. We consider the populations in the northern portion of the range to be the Great Lakes Snowbelt Unit with the Niagara Escarpment (Ontario and Michigan) and Onondaga Escarpment (New York) subunits. We consider the populations in the southern portion of the range to be the Appalachian Karst Unit (Alabama and Tennessee). The AHTF has two distinct representative units that suggest there may be adaptive capacity across the species' range; however, the southern unit may have always been rare under current climatic conditions. While the Appalachian Karst Unit is distinct genetically and ecologically, we are uncertain what adaptive capacity may be found in the southern populations or what the overall impact the potential loss of this unit may have for the AHTF, generally. (USFWS, 2019)

**Redundancy:**

Redundancy describes the ability of a species to withstand catastrophic events by maintaining multiple, resilient, populations well-distributed within the species' ecological settings and across the species' historical range. The Great Lakes Snowbelt unit contains nearly all of the populations and individual plants. As a whole, this representative unit has 142 populations and appears to have a high number of resilient, well-distributed, populations and was determined to have High redundancy as no catastrophic event is likely to simultaneously affect so many well-distributed populations. The Appalachian Karst representative unit is depauperate in the number of populations found within it. Only two extant populations remain, and based on the number of known records, the AHTF may never have been extensively distributed in the previous 100 years. As a catastrophic event could eliminate half to all of the populations in this representative unit, and the majority of all known populations are already extirpated, this representative unit was determined to have Very Low redundancy. (USFWS, 2019)

**Number of Populations:**

Approximately 66 occurrences in U.S. (59 Protected, 7 unprotected) and 59 protected in Canada) (USFWS, 2020)

**Population Size:**

Approximately 96,500 (USFWS, 2020)

**Population Narrative:**

There are currently 59 protected populations (41 percent) of the AHTF in the United States and Canada, with 34 protected populations in Ontario and 25 protected populations in the United States (USFWS 2020, Appendix A). In the United States, most of the populations of the AHTF are protected: Michigan, Alabama, and Tennessee each have one unprotected population, and New York has four unprotected populations. Approximately, 62,000 plants (51 percent) occur at protected populations, and approximately 34,500 plants (28 percent) are partially protected, as several large populations in Ontario are extensive and not contained within parcels owned by a single landowner. Protection means that impacts from localized activities that cause extirpation or can heavily impact entire populations, such as development, quarrying, and logging, are not anticipated at these sites. In addition, habitat management efforts at protected sites include removal of invasive species, primarily in New York, and stewardship and planning efforts to limit

impacts, including recreation, to individual plants. (USFWS, 2020)

### ***Threats and Stressors***

**Stressor:** Habitat destruction or modification (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** American hart's-tongue fern is threatened throughout most of its range by trampling and habitat alteration or destruction caused by timber removal, quarrying or residential development. Quarrying operations destroyed three of New York's populations and could pose a threat to at least one of the remaining New York sites and two of the southern sites (Clemants in litt., Evans 1981). Timber removal at most of the sites would be expected to raise light levels and lower humidity levels to the detriment of the species. Alterations associated with residential or other development would, in most cases, either directly destroy the plants present or result in environmental changes that would make the sites unsuitable for American hart's-tongue fern. The Michigan sites that are on USFS lands should receive protection from habitat destruction. Timber harvest, quarrying, or other types of development are considered to be the most significant threats to the Ontario populations of the species (USFWS, 2012).

**Stressor:** Invasive plants (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** American hart's-tongue fern is threatened throughout most of its range by competition or shading from invasive plants. The invasive plant swallow-wort (*Vincetoxicum rossicum*) is the most serious threat to some populations of the species in New York and may eventually threaten all populations. Other invasive species affecting New York populations of American Hart's-tongue ferns include exotic honeysuckles (*Lonicera* spp.) and European buckthorn (*Rhamnus cathartica*) (Leopold, pers. comm. 2012). Leopold (unpublished data) noted the presence of invasive species at 8 out of 14 New York sites that were monitored during 2008. The southern populations remain vulnerable to extirpation by inadvertent trampling because of their small size and the steep precarious nature of their habitat (USFWS, 2012).

**Stressor:** Herbivory (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** While reports of herbivory affecting American hart's-tongue fern populations are not common, Marr (2006) observed fronds on some plants with holes or eroded margins. Slugs, snails, molds, and insects were suggested as possible causes; though, none were directly observed damaging frond tissues (USFWS, 2012).

**Stressor:** Inadequacy of existing regulatory mechanisms (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** American hart's-tongue fern is listed as endangered under Michigan's Endangered Species Protection Law (Act 451 of 1994, Part 365) and Tennessee's Rare Plant Protection and Conservation Act. In Michigan, taking is prohibited on all public and private lands. In Tennessee, taking is only restricted when the permission of the landowner or manager has not been obtained. In New York the species is protected under the Protected Native Plants Law that prohibits collection on State lands and states that removal of the fern from private lands without the landowner's permission is a violation of the law and subjects the violator to a \$25 fine. Alabama does not directly protect endangered and threatened plants. However, American hart's-tongue fern is protected as a form of cave life by the Alabama Cave Conservation Act of 1988. The species' current status on the Federal List of Endangered and Threatened Plants provides additional protection from taking on Federal lands. Protection from inappropriate commercial trade (utilizing plants of wild origin rather than cultivated material) is also provided (USFWS, 2012).

**Stressor:** Other natural or manmade factors affecting its continued existence (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** The loss of shade that resulted from this alteration of the canopy desiccated many of the ferns growing on the forest floor. Insect infestations that temporarily remove the leaves of the canopy or result in long-term damage or death to the trees found there remain a threat to the species. Mats of bryophytes were sometimes seen to slough off of boulders where American hart's-tongue ferns were found in Michigan, and in at least one case a mature fern was dislodged along with the moss mat in which it was positioned. While the cause or extent of bryophytes sloughing off boulders is not known, the loss of this substrate type could reduce availability of suitable sites for gametophyte development if it occurred throughout sites harboring occurrences of American hart's-tongue fern (USFWS, 2012).

## **Recovery**

### **Reclassification Criteria:**

Not available.

### **Delisting Criteria:**

1. It has been documented that at least 15 U.S. occurrences (2 in Alabama, 2 in Tennessee, 4 in Michigan, and 7 in New York) are self-sustaining and occur on sufficiently large tracts to ensure their perpetuation with a minimal amount of active management (USFWS, 1993).

2. All of the populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (USFWS, 1993).

### **Recovery Actions:**

- Protect existing populations and essential habitat (USFWS, 1993).
- Determine and implement management necessary for long-term reproduction, establishment, maintenance, and vigor (USFWS, 1993).
- Maintain cultivated sources for the species and provide for long-term maintenance of selected populations in cultivation (USFWS, 1993).

- Enforce laws protection the species and/or its habitat (USFWS, 1993).
- Develop materials to inform the public about the status of the species and the recovery plan objectives (USFWS, 1993).
- Annually assess the success of recovery efforts for the species (USFWS, 1993).
- Develop and implement a program to control swallow-wort at sites harboring American hart's-tongue populations in New York and to provide for early detection and removal from sites in Michigan. This task is urgent given the prevalence of this threat to populations in New York and the rapid expansion of swallow-wort that has been seen in sites where American hart's-tongue fern occurs.
- Fund and coordinate range-wide surveys of all populations at two to five-year intervals (USFWS, 2012).
- Conduct long-term monitoring of microenvironmental characteristics of sites in Tennessee and Alabama to document ranges of variability in factors such as humidity, soil moisture, solar insolation, abundance of bryophytes and herbaceous vascular plants, and canopy cover. These data will be necessary to evaluate whether regional changes in climate patterns affect site suitability at the localized scale (USFWS, 2012).
- Provide protection for the remaining occupied sites in Tennessee and Alabama (USFWS, 2012).
- Conduct detailed genetic studies of the species throughout North America to assess population genetic structure and to guide potential reintroduction/augmentation projects in Tennessee and Alabama (USFWS, 2012).
- Continue developing propagation techniques for the southern populations of American hart's-tongue and evaluate potential for augmenting or reestablishing populations at these sites using sporophyte material produced from collections made at southern sites (USFWS, 2012).
- Develop and implement a program to ensure that damage to or destruction of overstory trees by insect pests at occupied sites does not permanently alter site microclimate to the extent that the sites are no longer suitable for American Hart's-tongue fern (USFWS, 2012).

***Conservation Measures and Best Management Practices:***

- RECOMMENDATIONS FOR FUTURE ACTIONS Develop an appropriate Post-Delisting Monitoring Plan based on the biology of the species in coordination with the affected Service regions and States. (USFWS, 2020)

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## SPECIES ACCOUNT: *Cyathea dryopteroides* (Elfin tree fern)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 6/16/1987; Southeast Region (Region 4) (USFWS, 2015)

### **Physical Description**

A small or dwarf tree fern reaching 24 inches (60 centimeters) in height and approximately 1 inch (2 to 3 centimeters) in diameter. The fronds are bipinnate, nearly hairless, tape at both ends, and reach 36 inches (90 centimeters) in length and 10 inches (25 centimeters) in width. The sori are located dorsally and are enclosed in a cup-shaped indusium. (USFWS, 1990)

### **Taxonomy**

Not Available

### **Historical Range**

Based on historical records of the elfin tree fern, the species seem to be associated to small remnants of dwarf forest vegetation at the highest elevation points of Puerto Rico, particularly to shady forest of sierra palm (*Prestoea acuminata*) with a relatively open understory (Omar Monseguir, USFWS, pers. comm., 2012). (USFWS, 2013)

### **Current Range**

Only three populations are known for the elfin tree fern. It is found on three peaks located approximately 12 miles (20 kilometers) apart, Monte Guilarte, Cerro Rosa and Monte Jayuya. A total of approximately 95 individuals have been located at these three sites. (USFWS, 1990)

### **Critical Habitat Designated**

Yes;

### ***Life History***

### **Food/Nutrient Resources**

### **Reproduction Narrative**

Adult: Not available

### **Habitat Vegetation or Surface Water Classification**

Adult: Subtropical lower montane wet forest (USFWS, 1991)

### **Geographic or Habitat Restraints or Barriers**

Adult: Occurs at elevations between 3,900 - 4,260 ft. (USFWS, 1991)

### **Dependency on Other Individuals or Species for Habitat**

Adult: Sierra palm (USFWS, 1991)

### **Habitat Narrative**

Adult: Dwarf forests and elfin forests in central mountains of Puerto Rico. Evergreen montane forest seldom exceeding 7 meters in height. Elfin forest usually found on rounded



mountaintops. Commonwealth forests of Toro Negro and Monte Guilarte. Described as subtropical lower montane wet forest and subtropical wet forest life zones. Species is usually a component of the groundcover within almost pure stands of sierra palm. The evergreen forest is characterized by a single canopy layer (~22 ft.), dense thickets, and mosses, liverworts, and bromeliads. Elevations at known sites range from 3900 to 4260 ft. (USFWS, 1991). The species characteristic of being associated with remnants of dwarf forest vegetation may indicate that it is associated to late successional vegetation (USFWS, 2013).

### ***Dispersal/Migration***

#### **Dispersal/Migration Narrative**

Adult: Not available

### ***Population Information and Trends***

#### **Population Trends:**

Unknown (USFWS, 2013)

#### **Species Trends:**

Uncertain (USFWS, 2013)

#### **Number of Populations:**

4 (USFWS, 2013)

#### **Population Narrative:**

The species status is uncertain; the status and distribution of the elfin tree fern has not been re-evaluated since 1981 (Proctor 1989). The elfin tree fern is known from four populations. Overall, the populations of the elfin tree fern have been poorly monitored and no information on population trends and demographic features are currently available (USFWS, 2013).

### ***Threats and Stressors***

**Stressor:** Development (USFWS, 2013)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Although the known populations are located within Commonwealth Forests, these areas may be subjected to development for expansion of telecommunication infrastructure. Both the final listing rule (52 FR 22936) and the species' recovery plan (USFWS 1991) indicate that the construction of new communication facilities or expansion of existing ones would affect the elfin tree fern. In Puerto Rico, towers for cellular communication, radio, television, military and governmental purposes have long represented a threat to those plant species that happen to occur on mountaintops. Their proliferation has increased with the advent of cellular phone and related technologies. While the towers themselves may not occupy a very large area, associated construction activities, access roads and facilities have a much wider impact, resulting in the elimination of potential habitat for the species. Additionally, construction of new access road and trails were identified as a factor that could directly (i.e., destruction of individuals) or indirectly (i.e., slope instability) reduce the number of elfin tree fern and its habitat at Monte Jayuya (Omar

Monsegur, USFWS, pers. comm., 2012).

**Stressor:** Vegetation management and road maintenance (USFWS, 2013)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Currently, vegetation management around the existing telecommunication towers and associated facilities, and along the existing power lines that service these facilities may be a threat to the fern and its habitat (Monsegur and Saliva, USFWS, unpubl. data, 2012). Mr. José R. Román (former manager of the Toro Negro Commonwealth Forest, pers. comm., 2012), states that the telecommunication companies and the Puerto Rico Energy and Power Authority (PREPA) conduct maintenance activities such as trimming and clearing the vegetation without coordination with the forest manager, affecting the forest vegetation, including the elfin tree fern habitat. Road maintenance activities were also identified as being a factor that could directly or indirectly reduce the number of plants near roads (USFWS 1991). Since the population dynamics of the species is poorly known, we understand that the impacts discussed above could be detrimental to the species as a whole. Clearing of vegetation may result in direct (i.e., cutting of individuals) or indirect impacts (i.e., by opening forest gaps that can serve as corridors for invasives) to the species (USFWS, 2013).

**Stressor:** Small population size and limited distribution (USFWS, 2013)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** The most important factors affecting the continued existence of the elfin tree fern are its limited distribution, low reproductive capacity and highly specialized ecological requirements. In the Caribbean, native plant species, particularly endemics with limited distribution, may be vulnerable to natural or anthropogenic events such as hurricanes, landslides, human induced fires and reduced genetic variation. The elfin tree fern is more susceptible to natural disturbances such as hurricanes or landslides, because it is confined to geographically small areas (USFWS 1991) (USFWS, 2013).

**Stressor:** Invasive species (USFWS, 2013)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Invasive native plants such as the fern *Gleichenella pectinata* may invade and alter diverse native dwarf forest communities, often resulting in plant monocultures that support few wildlife species (Omar Monsegur, USFWS, pers. obs., 2012). *Gleichenella pectinata* colonize disturbed areas faster than other native plants, thereby excluding native plants. *Gleichenella pectinata* may grow as an invasive by forming dense mats. Although the mats formed by this species serve as fuel for human induced fires, it seems to be fire tolerant (Omar Monsegur, USFWS, pers. obs., 2012). This invasive fern is currently found occupying areas disturbed by fire, landslides and road construction. If *G. pectinata* continues to spread and colonizes the elfin tree fern habitat, it could alter fire regimes, microclimate and nutrient cycling of the habitat that elfin tree ferns depend on. Furthermore, the native vine-like fern *Hypolepis repens* was observed in the area colonizing forest gaps probably created by previous hurricanes and growing over the elfin tree fern in Monte Jayuya (Monsegur and Saliva, FWS, unpubl. data, 2012) (USFWS, 2013).

**Stressor:** Fire (USFWS, 2013)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Human induced fire is a current threat for the species at Cerro Guilarte and Monte Jayuya. Areas potentially used by the species in Cerro Guilarte and Monte Jayuya have been affected by human induced fires (Omar Monsegur, USFWS, 2012, pers. obs.). The invasive species found in the area are fire-tolerant and make these sites susceptible to human-induced catastrophic fires. Since fires are not natural to this particular habitat, the native flora is not adapted to such disturbance. Fire effects could accelerate the colonization of invasive plants such as *Gleichenella pectinata* and change the vegetation composition of Monte Jayuya (see discussion under Factor A). The fern *Gleichenella pectinata* seems to be fire tolerant and form mats of dry material that serve as fuel for human induced fires. Although this invasive fern is located in the moist forest, during the dry season human-induced fires have been documented by the Service (Omar Monsegur, USFWS, 2012, pers. obs.) (USFWS, 2013).

**Stressor:** Stochastic events (USFWS, 2013)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Hurricanes or tropical cyclones frequently affect the islands of the Caribbean. Hurricanes contribute to shaping vegetation and ecosystem processes, being it a factor in determining the structure and composition of biotic communities in the Caribbean forest (Walker et al. 1991, Lugo 2000). Hurricane winds often lead to tree defoliation, loss of small and large branches, and up-rooted trees, resulting in damage to adjacent trees and understory plants when trees or branches fall and direct light damage to leaves of understory juveniles exposed to high light levels and temperature (Brokaw and Walker 1991). Additionally, high rainfall associated with tropical storms and hurricanes, sometimes about 24 inches (2 feet) of rain in a single storm event, can cause floods and interacts with topography and geologic substrate to induce mass wasting events, e.g. landslides (Lugo 2000). Changes in climate can have a variety of direct and indirect impacts on species, and can exacerbate the effects of other threats. An expected effect of climate change is the increase in the intensity of hurricanes and storms, followed by extended periods of drought (IPCC 2012). Climate change may alter (modify) the surrounding vegetation around the populations of the elfin tree fern (USFWS, 2013)

**Stressor:** Inadequacy of existing regulatory mechanisms

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Factor D (inadequacy of existing regulatory mechanisms) is now considered a threat for the elfin tree fern (USFWS 2013a), but not for Cook's holly (USFWS 2013b).

### **Recovery**

#### **Reclassification Criteria:**

At least two new populations capable of self-perpetuation have been established within protected units of the Commonwealth Forests (Monte Guilarte or Toro Negro) or on Federal

land within the Caribbean National Forest (now El Yunque National Forest) (USFWS, 2013).

**Delisting Criteria:**

The amended delisting criteria for the elfin tree fern and Cook's holly are as follows: 1. Threat reduction and management activities have been implemented to a degree that the species will remain viable into the foreseeable future (addresses Factors A, B, D and E). 2. The existing six (6) populations of elfin tree fern and the two (2) populations of Cook's holly within protected areas (Commonwealth Forests) show a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factors A and E). 3. Establish two (2) additional populations of each the elfin tree fern and the Cook's holly within protected areas that shows a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factors A and E) (USFWS, 2017).

**Recovery Actions:**

- Monitor existing populations (USFWS, 1990).
- Protect current habitat (USFWS, 1990).
- Conduct research on the life history of these species, evaluate methods of propagation and to look for reintroduction sites (USFWS, 1990).
- Propagate and produce seedlings for enhancement of existing populations and the establishment of new populations (USFWS, 1990).
- Develop a long-term management and monitoring protocol of natural and established populations to reduce site-specific threats for elfin tree fern and Cook's holly and its habitat. These recovery actions should be coordinated with PRDNER and be included within Task 121; Monitor all known populations of the approved recovery plan (USFWS, 2019).
- Evaluate the abundance and distribution of the elfin tree fern through surveys within traditional and non-traditional sites, using habitat models and best available plant survey methodology to determine current population numbers (USFWS, 2013).
- Identify the number of viable populations necessary to protect and stabilize the elfin tree fern population (wild, naturally-reproducing populations large enough to maintain sufficient genetic variation, and evolve and respond to natural habitat changes) (USFWS, 2013).
- Appropriate government agencies should continue evaluating and implementing conservation measures to minimize possible adverse effects to this fern from construction, improvement of communication facilities, and construction/expansion of roads and trails in Toro Negro and Guilarte Commonwealth forests (USFWS, 2013).
- As new information is gained on the species, delisting criteria should be developed (USFWS, 2013).
- Studies should be conducted on the species' phenology and its habitat requirements (USFWS, 2013).
- Propagation techniques should be evaluated and developed for the species as new information is gained in order to establish new self sustainable populations in protected areas (USFWS, 2013).

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## SPECIES ACCOUNT: *Isoetes louisianensis* (Louisiana quillwort)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 10/28/1992; Southeast Region (R4) (USFWS, 2015)

### **Physical Description**

A semi-aquatic, primitive, seedless plant related to ferns. Produces numerous grass-like leaves that vary in length from 15 to 40 cm long depending on water depth. The leaves arise from a fleshy, 2-lobed stem that is shallowly rooted in the substrate. The plants produce spores in early spring and in the fall. (NatureServe, 2015)

### **Taxonomy**

This species represents a polyphyletic assemblage, meaning all the tetraploid populations identified as *I. louisianensis* do not represent the same biological entity (Heafner 2009). (NatureServe, 2015)

### **Historical Range**

Not Available

### **Current Range**

Occurs in ten counties in southern Mississippi, as well as St. Tammany and Washington Parishes in adjacent eastern Louisiana and Monroe and Conecuh Counties in nearby southern Alabama (Moore and Leonard 1996, Sorrie and Leonard 1999). Range extent is approximately 22,000 square km. (NatureServe, 2015)

### **Critical Habitat Designated**

Yes;

### ***Life History***

### **Food/Nutrient Resources**

### **Reproductive Strategy**

Adult: Sexual (USFWS, 1996)

### **Breeding Season**

Adult: Winter to spring (inferred from EPA, 2016)

### **Key Resources Needed for Breeding**

Adult: Warm, wet conditions (USFWS, 1996)

### **Reproduction Narrative**

Adult: Fruiting is weather dependent and occurs from late spring through fall (EPA, 2016). Apparently, if conditions are warm and wet enough, sporangia develop and spores mature. After fertilization of the gametophyte, young sporophytes can emerge close to the parent sporophyte in a manner observed by Thieret (1980) and Taylor and Luebke (1986) and take root nearby or be dispersed downstream. This process may explain the often dense growth patterns in

quillwort population (USFWS, 1996).

**Habitat Type**

Adult: Aquatic, riparian (NatureServe, 2015)

**Habitat Vegetation or Surface Water Classification**

Adult: Riverine, palustrine, riparian woodland, pine flatwoods (NatureServe, 2015)

**Dependencies on Specific Environmental Elements**

Adult: Flowing water (inferred from NatureServe, 2015)

**Spatial Arrangements of the Population**

Adult: Linear (inferred from NatureServe, 2015), clumped (see reproduction narrative)

**Environmental Specificity**

Adult: Narrow (NatureServe, 2015)

**Site Fidelity**

Adult: High (see dispersal/migration narrative)

**Habitat Narrative**

Adult: Appears to be restricted to shallow blackwater streams in riparian woodland and bayhead forest areas of pine flatwoods. The plants are found on stable sand and gravel bars, moist overflow channels with silty sand substrates, and on low, sloping banks near and below water level. The environmental specificity is narrow, as it requires specific hydrology, water quality, and substrate characteristics in order to thrive. (NatureServe, 2015). It usually occurs under closed canopy. Typical colonies in south-central Mississippi occur in shallowly entrenched, intermittent streams lined with trees and some herbaceous cover. Also many tree roots bisecting the streams. Towards the coast of Mississippi and Louisiana, the habitat encompasses perennial streams with bald cypress. In Alabama, one colony occurs in a spring-like seepage with sandy muck soil and bald cypress that drains into a permanent creek. The other colony is along the margins of a grassy meadow and small hardwood swamp (EPA, 2016).

***Dispersal/Migration*****Dispersal**

Adult: Low (USFWS, 1996)

**Dispersal/Migration Narrative**

Adult: When Louisiana quillwort was first discovered, Thieret (1980) collected live plants with surrounding soil and cultivated them in a greenhouse at the University of Southwestern Louisiana. Plants were still thriving after 6 months. Thieret noted that “numerous young quillwort plants appeared in the soil of the pots. Many of these, while still only about 1 cm long and still attached to the megaspore, floated to the surface of the water.” He postulated that this phenomenon could be evidence, in natural conditions, for downstream dispersal of young plants. Taylor and Luebke (1986) experimented with spore germination and growing sporelings of aquatic species of Isoetes. They speculate (pers. comm. 1996) that the spiny surface ornamentation of microspores (and to a lesser degree, megaspores) may lend itself to trapping,

as spores become caught in the bases of the parent or nearby plants, or become embedded in soil nearby. In this manner, spores maintain close proximity to the colony despite sometimes swift water currents (USFWS, 1996).

### ***Population Information and Trends***

#### **Population Trends:**

Decline of 30-70% (NatureServe, 2015)

#### **Species Trends:**

Stable (USFWS, 2012)

#### **Number of Populations:**

20 (USFWS, 2024)

#### **Population Size:**

10,000 - 70,000 (NatureServe, 2015)

#### **Minimum Viable Population Size:**

Unknown (USFWS, 2012)

#### **Population Narrative:**

This species has experienced a long-term decline of 30-70%. The total population appears to be between 10,000 and 70,000 plants. Approximately 30 occurrences are believed to have excellent or good viability (NatureServe, 2015). The species status is stable, based on the 2011 Data Recovery Call. It is still unknown what the likely minimum number of populations is required to maintain genetic diversity and continued survival of Louisiana quillwort. Currently, there are 20 populations of Louisiana quillwort known from streams in 20 watersheds and 42 subwatersheds across southern portions of three states: Alabama, Louisiana, and Mississippi (USFWS, 2012). Louisiana quillwort is currently known from 20 populations in 3 states (Alabama, Louisiana, and Mississippi) distributed among 20 watersheds, 45 subwatersheds, and 15 counties (Figure 1, Tables 1 and 2). In 2022, a new occurrence of Louisiana quillwort was discovered in the Bayou Costapia subwatershed in Jackson County, Mississippi (Smith 2022a,b, pers. comms.), expanding the known population of the Tuxachanie Creek – Tchoutacabouffa River watershed (USFWS, 2024).

### ***Threats and Stressors***

**Stressor:** Development (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Increased development in Washington and St. Tammany Parishes, Louisiana and coastal Mississippi counties continue to threaten Louisiana quillwort colonies in these areas (Leonard 2011, Smith in litt. 2011). Louisiana quillwort colonies in Louisiana and Mississippi are threatened by road construction and maintenance (such as widening and bridge replacement) (Leonard 2011, Smith in litt. 2011). Pipeline construction and maintenance may also threaten populations in these states (Leonard 2011) (USFWS, 2012).



**Stressor:** Habitat modification (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Habitat modification, such as overstory clearing, continues to threaten colonies in Louisiana and Mississippi (U.S. Fish and Wildlife Service 1996, Faulkner et al. 2009, Leonard 2011). The current threat of gravel mining to colonies in Louisiana is unknown. Off-road vehicle use and hay production threaten one colony in Alabama (Leonard 2011) (USFWS, 2012).

**Stressor:** Wildlife disturbance (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Disturbance by rooting armadillos (*Dasypus novemcinctus*) has been noted on Camp Shelby Joint Forces Training Center (CSJFTC). It is unclear whether armadillos are searching for and consuming Louisiana quillwort corms, but the impact of such foraging activities on Louisiana quillwort populations and habitat appears minimal (Lyman in litt. 2011c). Significant soil disturbance by feral hogs (*Sus scrofa*) has been documented on CSJFTC and the associated Leaf River Wildlife Management Area, Mississippi (Leonard 2011, Lyman in litt. 2011c). Although it is unlikely that feral hogs are foraging for Louisiana quillwort corms (Leonard 2011), extensive soil disturbance by foraging hogs within stream channels and their associated floodplains pose a significant threat to existing populations of Louisiana quillwort as well as to suitable habitat (Leonard 2011, Lyman in litt. 2011c). Beaver dams and their associated ponds may threaten some colonies of Louisiana quillwort in Louisiana and Mississippi (Leonard 2011, Lyman in litt. 2011b). Beaver dams downstream of two monitoring plots on CSJFTC caused water to become too deep and turbid to see or measure plants (USFWS, 2012).

**Stressor:** Climate change (USFWS, 2012)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Wind-throw from hurricanes has the potential to reduce scouring by directly increasing litter accumulation and blocking stream flow, thus allowing greater accumulation of sediment in impacted stream systems (Leonard 2011). If climate change reduces rainfall rates or increases the frequency of hurricanes making landfall on Alabama, Louisiana, or Mississippi, Louisiana quillwort would likely be adversely affected (USFWS, 2012).

## ***Recovery***

### **Reclassification Criteria:**

Downlisting criteria were not identified in the recovery plan (USFWS, 2012).

Recovery Priority Number: 14

### **Delisting Criteria:**

10 viable and geographically distinct populations from distinctly separate drainages are protected. A viable population is one which is reproducing and stable or increasing in size as

shown by monitoring for at least a 10-year period (USFWS, 2012).

#### **Recovery Actions:**

- Protect known populations by protecting their habitat (USFWS, 1996).
- Conduct life history research (USFWS, 1996).
- Monitor population trends and developing threats (USFWS, 1996).
- Search for additional populations in southeastern Louisiana, southern Mississippi, and south Alabama (USFWS, 1996).
- Preserve genetic stock (USFWS, 1996).
- Inform the public about the conservation needs of the species (USFWS, 1996).
- Perform population status assessment updates (USFWS, 2012).
- Work with Federal and State entities, non-governmental organizations, and private individuals to permanently protect and manage existing habitats and populations (USFWS, 2012).
- Implement aggressive feral hog (*Sus scrofa*) control programs (USFWS, 2012).
- Search for additional populations on private lands, particularly around De Soto National Forest in Mississippi (USFWS, 2012).
- Implement demographic and habitat studies to more fully understand underlying drivers of population fluctuations (USFWS, 2012).
- Continue and expand conservation genetics work to include all watersheds with known occurrences (USFWS, 2012).
- Preserve additional genetic stock (USFWS, 2012).
- Update the recovery plan (USFWS, 2012).
- RECOMMENDATIONS FOR FUTURE ACTIONS • Perform population status assessment updates. • Work with Federal and State entities, non-governmental organizations, and private individuals to permanently protect and manage existing habitats and populations. • Implement aggressive feral hog (*Sus scrofa*) control programs. • Search for additional populations on private lands, particularly around De Soto National Forest in Mississippi. • Implement demographic and habitat studies to more fully understand underlying drivers of population fluctuations. • Continue and expand conservation genetics work to include all watersheds with known occurrences. • Preserve additional genetic stock. • Update the recovery plan. RECOMMENDATIONS FOR FUTURE ACTION The previous 5-year review included a list of recommendations to improve recovery of the species. Accomplishments toward these recommended actions are summarized below. A. Monitoring is inconsistent range-wide with only some populations in Mississippi receiving regular monitoring. B. Work with Federal partners to protect and manage the species has continued primarily under the Service's section 7 consultation provisions (e.g., USFS 2014). Annual meetings between multiple Federal and State agencies, Mississippi Army National Guard personnel and staff, and TNC at Camp Shelby Joint Forces Training Center provide regular opportunities to discuss and address conservation of Louisiana quillwort and other species. The Service's Louisiana Ecological Services Field Office's Partners Program has provided funding to support land conservation on private lands that benefits at least one Louisiana quillwort population in Louisiana. C. Wild hog control efforts are underway, but would benefit from additional funding and focus on areas where Louisiana quillwort and wild hogs co-occur. D. Monitoring of and searches for Louisiana quillwort by TNC staff on Camp Shelby Joint Forces Training Center and by USFS staff on De Soto National Forest in Mississippi are ongoing. Likewise, periodic searches for the species occur throughout its range pursuant to section 7

consultation activities. However, limited efforts beyond section 7 related activities have been made to focus searches on private lands within the species' range since 2012. E. The Nature Conservancy in Mississippi has engaged in some demographic and habitat studies of Louisiana quillwort on Camp Shelby Joint Forces Training Center, but the study is ongoing and results have not been formally analyzed or evaluated and, therefore, insights from this work are currently limited. F. While some genetics work has been conducted since the last 5-year review, this work has primarily focused on the phylogenetics and species discrimination. G. No additional genetic material has been placed into ex situ safeguarding collections. To date, the single known ex situ safeguarding collection only contains material from Louisiana. H. The recovery plan still needs to be updated. In addition to the above accomplishments and remaining needs, the following activity is also recommended: I. A range-wide investigation of the species that includes morphological, habitat, and genetic studies is needed to resolve current and potential future discrepancies between field identifications and genetic identity of Louisiana quillwort records (USFWS, 2019).

***Conservation Measures and Best Management Practices:***

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery criteria and actions are presented in the species' Recovery Plan (Service 1996). During this status review, new and/or targeted potential recovery activities were identified and are included below. These actions are recommended to support and promote recovery of Louisiana quillwort. Use of a numbered list for these recommendations is for convenient reference only and does not necessarily imply prioritization of any activity over others. Recovery Activities 1. Continue working with Federal and State entities, non-governmental conservation organizations, and private individuals to permanently protect and manage existing habitats and populations. 2. Implement aggressive wild hog control programs. 3. Search for additional populations on private lands, particularly around De Soto National Forest in Mississippi. 4. Preserve additional genetic stock. Monitoring and Research Activities 1. Perform regular monitoring of populations and their habitats throughout the species' range. 2. Implement expanded demographic and habitat studies to more fully understand underlying drivers of population fluctuations. 3. Continue and expand conservation genetics work to include all watersheds with known occurrences (USFWS, 2024).

**References**

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

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## SPECIES ACCOUNT: *Isoetes melanospora* (Black spored quillwort)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 2/5/1988; Southeast Region (Region 4) (USFWS, 2015)

### **Physical Description**

A perennial fern ally that forms small tufts of erect to spreading, linear leaves, 2.5-8 cm tall, usually arranged spirally on the bulbous rootstock. Produces dark-colored megaspores (most other quillworts have whitish spores), mostly in early May to June. (NatureServe, 2015)

### **Taxonomy**

Distinct species, distinguished by its complete velum coverage, dark tuberculate megaspores, and short spiral leaves. (NatureServe, 2015)

### **Historical Range**

Known (historically) from 1 site in S. Carolina. (NatureServe, 2015)

### **Current Range**

Piedmont physiographic region in Georgia. (NatureServe, 2015)

### **Critical Habitat Designated**

Yes;

### **Life History**

### **Food/Nutrient Resources**

### **Food/Nutrient Narrative**

Adult: Moisture breaks dormancy, no matter what time of year it is. Dormancy caused by dry conditions. Plants switch from dormant to growing throughout the summer (USFWS, 1993).

### **Reproductive Strategy**

Adult: Sexual (USFWS, 1993)

### **Reproduction Narrative**

Adult: Sporelings are usually found late winter or early spring. When conditions are favorable for fertilization, a flap opens in the megaspore wall, exposing one or more funnel-like necks, through which the motile male gametes (spermatozoids) may enter and fertilize the single egg located at the base of each neck. Following fertilization, a single zygote develops into a sporophyte, enclosed within the megaspore wall. A single juvenile leaf and root are soon produced and after continued growth the old megaspore wall is shed. How rapidly plants reach sexual maturity under the extreme conditions of their habitat is unknown. In cultivation, they can reach maturity in at most a few years (USFWS, 1993).

### **Habitat Type**

Adult: Terrestrial, aquatic (NatureServe, 2015)

**Habitat Vegetation or Surface Water Classification**

Adult: Temporary pool, granite outcrops (NatureServe, 2015)

**Environmental Specificity**

Adult: Very narrow (NatureServe, 2015)

**Habitat Narrative**

Adult: Shallow, flat-bottomed, temporary pools that form in depressions on granite outcrops. These depressions are less than 3 dm deep and usually contain at least 2 cm of soil. They may be dry during much of the summer. Associated with other rare and endangered granite outcrop endemics, including *Amphianthus pusillus* (poolsprite). The environmental specificity of this species is very narrow (NatureServe, 2015). They sometimes occur in quarry pools formed on flat-to-doming granitic (either granite or granite-gneiss) outcrops. Outcrops are bare rock with small islands of vegetation present. Water is normally present in pools from late autumn to mid-spring (USFWS, 1993).

***Dispersal/Migration*****Dispersal/Migration Narrative**

Adult: Not available

***Population Information and Trends*****Population Trends:**

Not available

**Species Trends:**

Declining (USFWS, 2008)

**Number of Populations:**

12 (NatureServe, 2015)

**Population Size:**

> 10,000 (NatureServe, 2015)

**Adaptability:**

Low (inferred from USFWS, 2008)

**Population Narrative:**

In Georgia there are 12 extant occurrences in 6 counties. There are five populations with good viability/integrity. There is a single large population in excess of 10,000 individuals in Georgia at one of the Mt. Arabia sites; other populations tend to be 50 plants or fewer (NatureServe, 2015). The species status is declining, based on the 2007 Recovery Data call. This species is vulnerable due to limited potential habitat and specialized microhabitat requirements (USFWS, 2008).

***Threats and Stressors***

**Stressor:** Habitat destruction and modification (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Quarrying continues to be the primary threat destroying granite outcrops. Environmental conditions on the remaining outcrops are still being modified by cattle eutrophication, littering, trash dumping, fire building, vandalism, and off-road vehicles. Development within Atlanta has become a new threat resulting in substantial habitat destruction (USFWS, 2008).

**Stressor:** Environmental changes (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** As this species requires high light intensities (Lamer 1958), excessive tree growth is suspected to be a problem at a few sites, due to shading. A few pools appear to be moving toward a later stage of succession due to excessive soil accumulation. Abnormally low temperatures can also damage or kill populations (USFWS, 2008).

**Stressor:** Recreation (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Publicly owned sites are subjected to excess foot traffic, littering, or vandalism. Vehicular traffic is a serious problem at many sites (USFWS, 2008).

**Stressor:** Hybridization (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** At three outcrops, this species has seemingly been outcompeted by hybrids of *I. melanospora* and *I. piedmontana* (Matthews and Murdy 1969) (USFWS, 2008).

## **Recovery**

### **Reclassification Criteria:**

Reclassification of black-spored quillwort or mat-forming quillwort to threatened will be considered when the following conditions are met: 1. Ten (10) populations exhibit a stable or increasing trend, evidenced by natural recruitment. 2. All 10 populations occur on lands protected via a conservation mechanism (addressed listing Factor A and D). 3. All 10 populations consist of at least 2 pools each, the 2 pools for black-spored quillwort must be at least 6 m<sup>2</sup> (65 ft<sup>2</sup>) in size, and the 2 pools for mat-forming quillwort must be at least 5 m<sup>2</sup> (54 ft<sup>2</sup>) in size (addresses listing factor E) (USFWS, 2019).

### **Delisting Criteria:**

The black-spored quillwort and mat-forming quillwort will be considered for delisting when: 1. Fifteen (15) populations exhibit a stable or increasing trend, evidenced by natural recruitment. 2. All 15 populations occur on lands protected via a conservation mechanism (addressed listing

factor A and D). 3. All 15 populations consist of at least 2 pools each, the 2 pools for black-spored quillwort must be at least 6 m<sup>2</sup> (65 ft<sup>2</sup>) in size, and the 2 pools for mat-forming quillwort must be at least 5 m<sup>2</sup> (54 ft<sup>2</sup>) in size (addresses listing factor E) (USFWS, 2019).

**Recovery Actions:**

- Protect populations and habitat (USFWS, 1993).
- Preserve genetic stock from acutely threatened populations (USFWS, 1993).
- Monitor populations to determine trends and developing threats (USFWS, 1993).
- Search for additional populations (USFWS, 1993).
- Reestablish populations and augment extant populations at protected locations, if deemed necessary (USFWS, 1993).
- Use management techniques to maintain and/or enhance populations (USFWS, 1993).
- Educate the public about the value and fragility of these species and their habitat (USFWS, 1993).
- **ADDITIONAL SITE SPECIFIC RECOVERY ACTIONS** Because of the extirpation of the amphianthus population at Rusty Rock (II.B.1.1.4. (page 16)), we strike this portion of the Recovery Actions. The amphianthus population is considered extirpated and has been since 1998. Since the last recovery plan, several efforts have been made to artificially create pools and augment populations of all three granite outcrop species. To Section II.B.5. "Reestablish populations and augment populations at protected locations, if deemed necessary" (page 20), we would like to add the following information about population augmentation. Through partnerships with state, non-government, and other sources, populations at Heggie's Rock, Greensboro South, Bradley Mountain, Arabia Mountain, and Stone Mountain have all been modified through pool creation and/or pool modification. Artificial deepening of existing pools or artificially created pools should target the minimum pool size identified in the recovery 7 criteria for the species. Pool creation should target areas at the highest elevation (top of the watershed) of the outcrop and minimize impacts to surrounding landscape. Because of the natural geology of the sites, site choice should also assess likelihood of exfoliation fissures beneath the surface. When intersected, these fissures result in the failure of the pool to hold water. Coordination with the Service in determining locations, size, depth, and source populations should occur (USFWS, 2019).
- Future efforts to move plants need to develop a protocol and monitoring schedule prior to moving plants. Any protocol must consider how to limit the potential hybridization of black-spored quillwort with other Isoetes (USFWS, 2008).
- The effects of quarry dust should be investigated (USFWS, 2008).
- Conservation priorities need to be developed that protect and/or enhance this plant as well as other community associates of the granite outcrop. At outcrops with conservation potential, the land owners need to be contacted to seek conservation easements or fee simple acquisition. The Service and State Heritage programs should contact private landowners to request their cooperation in plant conservation.
- Status surveys need to be completed for this species in all three States (USFWS, 2008).

**Conservation Measures and Best Management Practices:**

- **RECOMMENDATIONS FOR FUTURE ACTIONS:** Before any future efforts to move any of the three plants, we along with partners need to develop a protocol and monitoring schedule prior to moving plants. Any protocol must consider how to limit the potential of hybridization of black-spored quillwort with other Isoetes. Little amphianthus cannot reasonably be expected to be kept in



cultivation, therefore, an effort to maintain seed stock from the various pools should be established. The implications of seed storage should be studied to evaluate germination success and techniques. The recovery plan suggested that the effects of quarry dust should also be investigated. Management plans for each of the protected populations should be developed to ensure that future uses of the property (e.g. film industry use and increasing pressures for expanding populations). Studies should be conducted to assess the status of the introduced populations and the viability of plants in the artificial pools. Because most natural pools of both quillworts are larger than the artificially-created pools, these pools may be less resilient to drying out and may not hold water long enough for the species to persist when facing variability in water availability. Efforts may be beneficial to create and research differing pool sizes and depths to understand their impacts on species viability. Conservation priorities need to be developed that protect and/or enhance each of these listed plants as well as other community associates of the granite outcrop. At outcrops with conservation potential, the landowners need to be contacted to seek conservation easements or fee simple acquisition. The Service and State Heritage programs should continue to contact private landowners to request their cooperation in plant conservation. Status surveys need to be continued for these species in all three States. The Implementation schedule in the recovery plan needs to be updated. (USFWS, 2019a)

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## SPECIES ACCOUNT: *Isoetes tegetiformans* (Mat-forming quillwort)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 2/5/1988; Southeast Region (Region 4) (USFWS, 2015)

#### **Physical Description**

An aquatic perennial fern ally that forms mats of prostrate-arching rhizome-like structures on or near the soil surface. Arising from these are erect to spreading, linear leaves, 3-7 cm long, arranged in 2 rows along the "rhizome." Spores are dark-colored (unlike most other quillworts, which have whitish spores), and are produced mostly from early May to October. This unique species is considered to be the most distinctive quillwort in North America. (NatureServe, 2015)

#### **Taxonomy**

Not Available

#### **Historical Range**

Not available

#### **Current Range**

Only Greene and Columbia Counties, Georgia. Reports from North Carolina are in error (i.e. Federal Register list). Fairly intensive work in western Georgia, South Carolina and North Carolina has not revealed this species.

#### **Critical Habitat Designated**

Yes;

#### ***Life History***

#### **Food/Nutrient Resources**

#### **Food/Nutrient Narrative**

Adult: Moisture breaks dormancy, no matter what time of year it is. Dormancy caused by dry conditions. Plants switch from dormant to growing throughout the summer.

#### **Reproductive Strategy**

Adult: Sexual, clonal (USFWS, 1993)

#### **Reproduction Narrative**

Adult: Sporadic spore production occurs from May to October. This species exhibits sexual and clonal reproduction (USFWS, 1993).

#### **Habitat Type**

Adult: Aquatic, terrestrial (NatureServe, 2015)

#### **Habitat Vegetation or Surface Water Classification**

Adult: Palustrine: temporary pool; terrestrial: bare rock/talus/scree, barrens (NatureServe, 2015)

**Spatial Arrangements of the Population**

Adult: Clumped (NatureServe, 2015)

**Environmental Specificity**

Adult: Narrow (inferred from NatureServe, 2015)

**Habitat Narrative**

Adult: Shallow, flat-bottomed, temporary pools that form in depressions on granite outcrops. These depressions are less than 3 cm deep and usually contain at least 2 cm of soil. They may be dry during much of the summer. It requires an exacting combination of weather factors to grow to maturity. It is a rhizomatous colony-forming species (NatureServe, 2015). Outcrops are bare rock with small islands of vegetation present. Water is normally present in pools from late autumn to mid-spring (EPA, 2016). This is a colony-forming species (Bridges 1986a) (USFWS, 2008).

***Dispersal/Migration*****Dispersal/Migration Narrative**

Adult: Not available

***Population Information and Trends*****Population Trends:**

Stable (USFWS, 2019a)

**Species Trends:**

Stable (USFWS, 2019a)

**Number of Populations:**

7 (NatureServe, 2015)

**Population Size:**

1000 - 2500 individuals (NatureServe, 2015)

**Adaptability:**

Low (USFWS, 2008)

**Population Narrative:**

Only 7 small populations are known to be surviving. It occurs only in 2 counties in GA (NatureServe, 2015). The species status is declining, based on the 2007 Recovery Data Call. It has limited genetic diversity and may have limited ability to adapt to environmental change (USFWS, 2008). Historically, mat-forming quillwort was known to occur at 11 granite outcrops across Georgia (Service 1988). In the last 5-year review, there were 9 extant populations comprised of 13 EOs. Please refer to section C.1.a. for a description of our approach to defining populations for this species. There are currently 11 extant populations of mat-forming quillworts, including 2 of unknown condition (the populations have not been visited since the last 5-year review), 2 introduced populations, 1 created population, and 6 additional populations. Of the two

introduced populations, one is in a single pool at an arboretum and the other is in a single pool on private property (Thompson Mill Forest Arboretum and Siloam). Both of these introduced populations are not considered self-sustaining because the introductions are in less than ideal outcrop habitat, both populations are outside the known historic range of mat-forming quillwort, and they were introduced with black-spored quillwort which could result in hybridization. Since the last 5-year review, one new population was found (Rocky Comfort), one population was created (Greensboro South), and one population has improved in its condition status (Forty Acre Rock, GA). Three of the natural, extant populations and one introduced population occur on protected lands (e.g. state, county, and private conservation lands). (USFWS, 2019a)

### ***Threats and Stressors***

**Stressor:** Habitat destruction and modification (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Quarrying continues to be the primary threat destroying granite outcrops. Environmental conditions on the remaining outcrops are still being modified by cattle eutrophication, littering, trash dumping, fire building, vandalism, and off-road vehicles. Development in Atlanta has become a new threat to this habitat (USFWS, 2008).

**Stressor:** Excessive tree growth (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** As this species requires high light intensities (Lamar 1958), excessive tree growth is suspected to be a problem at a few sites, due to shading (USFWS, 2008).

**Stressor:** Recreation (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Publicly owned sites are subjected to excess foot traffic, littering, or vandalism. Vehicular traffic is also a serious problem at many sites (USFWS, 2008).

**Stressor:** Hybridization (USFWS, 2008)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** New evidence shows *I. tegetiformans* may also suffer from hybridization (USFWS, 2008).

### ***Recovery***

**Reclassification Criteria:**

10 viable and geographically distinct populations (separate outcrops), each with at least two occupied pools, are protected from any foreseeable threats (USFWS, 1993).

Reclassification of black-spored quillwort or mat-forming quillwort to threatened will be considered when the following conditions are met: 1. Ten (10) populations exhibit a stable or increasing trend, evidenced by natural recruitment. 2. All 10 populations occur on lands protected via a conservation mechanism (addressed listing Factor A and D). 3. All 10 populations consist of at least 2 pools each, the 2 pools for black-spored quillwort must be at least 6 m 2 (65 ft<sup>2</sup>) in size, and the 2 pools for mat-forming quillwort must be at least 5 m 2 (54 ft<sup>2</sup>) in size (addresses listing factor E) (USFWS, 2019).

**Delisting Criteria:**

The black-spored quillwort and mat-forming quillwort will be considered for delisting when: 1. Fifteen (15) populations exhibit a stable or increasing trend, evidenced by natural recruitment. 2. All 15 populations occur on lands protected via a conservation mechanism (addressed listing factor A and D). 3. All 15 populations consist of at least 2 pools each, the 2 pools for black-spored quillwort must be at least 6 m 2 (65 ft<sup>2</sup>) in size, and the 2 pools for mat-forming quillwort must be at least 5 m 2 (54 ft<sup>2</sup>) in size (addresses listing factor E) (USFWS, 2019).

**Recovery Actions:**

- Protect populations and habitat (USFWS, 1993).
- Preserve genetic stock from acutely threatened populations (USFWS, 1993).
- Monitor populations to determine trends and developing threats (USFWS, 1993).
- Search for additional populations (USFWS, 1993).
- Reestablish populations and augment extant populations at protected locations, if deemed necessary (USFWS, 1993).
- Use management techniques to maintain and/or enhance populations (USFWS, 1993).
- Educate the public about the value and fragility of these species and their habitat (USFWS, 1993).
- ADDITIONAL SITE SPECIFIC RECOVERY ACTIONS Because of the extirpation of the amphianthus population at Rusty Rock (II.B.1.1.4. (page 16)), we strike this portion of the Recovery Actions. The amphianthus population is considered extirpated and has been since 1998. Since the last recovery plan, several efforts have been made to artificially create pools and augment populations of all three granite outcrop species. To Section II.B.5. "Reestablish populations and augment populations at protected locations, if deemed necessary" (page 20), we would like to add the following information about population augmentation. Through partnerships with state, non-government, and other sources, populations at Heggie's Rock, Greensboro South, Bradley Mountain, Arabia Mountain, and Stone Mountain have all been modified through pool creation and/or pool modification. Artificial deepening of existing pools or artificially created pools should target the minimum pool size identified in the recovery 7 criteria for the species. Pool creation should target areas at the highest elevation (top of the watershed) of the outcrop and minimize impacts to surrounding landscape. Because of the natural geology of the sites, site choice should also assess likelihood of exfoliation fissures beneath the surface. When intersected, these fissures result in the failure of the pool to hold water. Coordination with the Service in determining locations, size, depth, and source populations should occur (USFWS, 2019).
- Any future efforts to move plants need to develop a protocol and monitoring schedule prior to moving plants. Any protocol must consider how to limit the potential hybridization of black-spored quillwort with other Isoetes (USFWS, 2008).

- The effects of quarry dust should be investigated (USFWS, 2008).
- Conservation priorities need to be developed that protect and/or enhance each of these listed plants as well as other community associates of the granite outcrop. At outcrops with conservation potential, the land owners need to be contacted to seek conservation easements or fee simple acquisition. The Service and State Heritage programs should contact private landowners to request their cooperation in plant conservation (USFWS, 2008).
- Status surveys need to be completed for these species in all three states (USFWS, 2008).

***Conservation Measures and Best Management Practices:***

- **RECOMMENDATIONS FOR FUTURE ACTIONS:** Before any future efforts to move any of the three plants, we along with partners need to develop a protocol and monitoring schedule prior to moving plants. Any protocol must consider how to limit the potential of hybridization of black-spored quillwort with other Isoetes. Little amphianthus cannot reasonably be expected to be kept in cultivation, therefore, an effort to maintain seed stock from the various pools should be established. The implications of seed storage should be studied to evaluate germination success and techniques. The recovery plan suggested that the effects of quarry dust should also be investigated. Management plans for each of the protected populations should be developed to ensure that future uses of the property (e.g. film industry use and increasing pressures for expanding populations). Studies should be conducted to assess the status of the introduced populations and the viability of plants in the artificial pools. Because most natural pools of both quillworts are larger than the artificially-created pools, these pools may be less resilient to drying out and may not hold water long enough for the species to persist when facing variability in water availability. Efforts may be beneficial to create and research differing pool sizes and depths to understand their impacts on species viability. Conservation priorities need to be developed that protect and/or enhance each of these listed plants as well as other community associates of the granite outcrop. At outcrops with conservation potential, the landowners need to be contacted to seek conservation easements or fee simple acquisition. The Service and State Heritage programs should continue to contact private landowners to request their cooperation in plant conservation. Status surveys need to be continued for these species in all three States. The Implementation schedule in the recovery plan needs to be updated (USFWS, 2019a)

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## SPECIES ACCOUNT: *Polystichum calderonense* (No common name)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 6/9/1993; Southeast Region (Region 4) (USFWS, 2015)

### **Physical Description**

An evergreen terrestrial fern. It has a curved-ascending, 7-mm-thick rhizome which is clothed at the apex with lanceolate to oblong, curved, shining black, marginate scales up to 10 mm long. The fronds are erect to spreading and may reach 60 cm in length. The twice-pinnate blades are lanceolate, 25 to 40 cm long, 6 to 14 cm broad, and narrowed and truncate at the apex. Blades terminate in a scaly proliferous bud which is somewhat narrowed toward the base. This species has 30 to 36 pairs of oblique, short-stalked pinnae. It has a characteristic 4- to 7-cm-long and 0.9- to 1.3-cm-broad middle pinnae. with 8 to 10 pairs of free pinnules. The tissue is dark green, rigid, and opaque. There are 1 to 5 sori located dorsally on the veins of each pinnule. but they are not clearly arranged in rows. The sori are covered by a light brown, deciduous, thin indusium (Proctor 1989). (USFWS, 1994)

### **Taxonomy**

Not Available

### **Historical Range**

Not Available

### **Current Range**

*Polystichum calderonense* is a terrestrial fern that when listed, was known only from the summit of La Silla de Calderon in the Guilarte Commonwealth Forest, and from a private property in Monte Cerrote, in the municipality of Peñuelas (Proctor 1991, USFWS 2010). For these two populations, Proctor (1991) reported 45 and 12 individuals, respectively. However, Jeanine Velez (University of Puerto Rico, Mayaguez Campus) described a third population at the Summit of Monte Guilarte (pers. comm. as cited in Possley and Lange 2016), the fifth highest peak in Puerto Rico (elevation 3,934 ft (1,199 m)). Nevertheless, Possley and Lange (2017) surveyed the area and were unable to find any individuals. An average of 14 plants and recruitment were reported at Silla de Calderon between 2014 and 2017 (Possley and Lange 2017). During these surveys, Possley and Lange (2017) along with Service staff noticed invasive plants species encroaching the area, and remnants of human induced fires just neighboring the *P. calderonense* individuals. On both localities (i.e., Silla Calderon and Monte Guilarte) Possley and Lange (2017) also discovered pockets of suitable habitat for the species. The current status of *P. calderonense* at Monte Cerrote remains unknown. This area has not been surveyed since 1991 (USFWS, 2019).

### **Critical Habitat Designated**

Yes;

### **Life History**

### **Food/Nutrient Resources**

**Reproduction Narrative**

Adult: Not available

**Habitat Vegetation or Surface Water Classification**

Adult: Subtropical wet forest and subtropical moist forest (USFWS, 1994)

**Geographic or Habitat Restraints or Barriers**

Adult: ~3280 to 3772 ft. elevation (USFWS, 1994)

**Environmental Specificity**

Adult: Narrow (inferred from USFWS, 1994)

**Habitat Narrative**

Adult: Grows on moist, shady non-calcareous ledges on mountain tops in central and south-central Puerto Rico. Forest is described as subtropical wet forest and subtropical moist forest life zones. It occurs around 3280 to 3772 ft. elevation (USFWS, 1994)

***Dispersal/Migration*****Dispersal/Migration Narrative**

Adult: Not available

***Population Information and Trends*****Population Trends:**

Not available

**Species Trends:**

Uncertain (USFWS, 2010)

**Number of Populations:**

3 (USFWS, 2022)

**Population Size:**

< 100 (USFWS, 2010)

**Population Narrative:**

The specie status is uncertain; no recent surveys have been conducted for these species and the current population numbers are not known. It is known from two localities comprising less than 100 individuals (USFWS, 2010). *Polystichum calderonense* is an evergreen terrestrial fern only known from three localities: the summit of La Silla de Calderón, the summit of Monte Guilarte Commonwealth Forest, both in the municipality of Adjuntas and Cerrote Peñuelas in the municipality of Peñuelas (USFWS, 2022).

***Threats and Stressors***

**Stressor:** Habitat destruction and modification (USFWS, 2010).

**Exposure:**

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

**Narrative:** Polystichum calderonense is threatened by unplanned forest management practices conducted in Commonwealth forests. This species was identified by Proctor (1991, p.153) as vulnerable to cutting or fires. In Peñuelas, according to the Recovery Plan, this species occurs in private lands which may be affected by industrial or residential development (USFWS, 2010).

**Stressor:** Small population size (USFWS, 2010).

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

**Narrative:** Small population numbers make this species particularly vulnerable to extinction due to the lack of genetic variation necessary to evolve and respond to natural changes.

**Recovery****Reclassification Criteria:**

1. The known populations are placed under protective status (USFWS, 1994).
2. An agreement between the Service and the DNER concerning the protection of this species in Commonwealth forests has been developed and implemented (USFWS, 1994).
3. An agreement between the Service and Cornell University concerning the protection of Tectaria estremerana on the Arecibo Radio Telescope property has been prepared and implemented (USFWS, 1994).
4. New populations (the number of which should be determined following the appropriate studies) capable of self perpetuation have been established within protected areas (USFWS, 1994).

Recovery Priority Number: 5

**Delisting Criteria:**

The amended delisting criteria for Elaphoglossum serpens, Polystichum calderonense, Tectaria estremerana, Thelypteris inabonensis, Thelypteris verecunda, and Thelypteris yaucoensis are as follows: 1. Existing populations (number populations in parentheses) of E. Serpens (2), P. calderonenses (3), T estremerana (3), T verecunda (3), Tinabonensis (2) and T yaucoensis (2) show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and Factor E). 2. Establish or discover new populations (number of populations in parentheses) within the historical range of E. serpens (3), T inabonensis (3), T yaucoensis (3), P calderonense (2), T. estremerana (2), and T. verecunda (2) that show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and 3. Threat reduction and management activities have been implemented to a degree that the species is viable for the foreseeable future (addresses Factor A and E) (USFWS, 2019).

**Recovery Actions:**

- Prevent further habitat loss and population decline (USFWS, 1994).
- Continue to gather information on the distribution and abundance of the seven endangered ferns (USFWS, 1994).
- Conduct research on habitat requirements, reproductive biology, and ecology of the seven species (USFWS, 1994).
- Establish new populations (USFWS, 1994).
- Refine recovery goals (USFWS, 1994).
- Evaluate abundance and distribution through surveys within traditional and non-traditional sites, using the best available plant survey methodology to determine current population numbers, and number of viable populations necessary to protect and stabilize populations (wild, naturally reproducing populations large enough to maintain sufficient genetic variation, and evolve and respond to natural habitat changes) (USFWS, 2010).
- Appropriate government agencies should continue evaluating and implementing conservation measures to minimize possible adverse effects of construction/improvement of communication facilities and forest management practices in Commonwealth forests (USFWS, 2010).
- Review and modify the Puerto Rican Endangered Ferns Recovery Plan which includes these three species to establish delisting criteria. Recovery tasks should be reviewed and implemented (USFWS, 2010).
- Propagation techniques should be developed for the species to establish new self sustainable populations in protected areas (USFWS, 2010).
- Considering all these factors, we recommend the following:
  - The habitat of the two (2) known populations of *E. serpens* occurring on protected land (i.e., Cerro Punta and Monte Jayuya) need to be fully assessed, and populations enhanced to ensure their resiliency. Specifically, Possley and Lange (2017), and Service biologist O. Monsegur-Rivera recommend a more comprehensive survey that covers a wider area and expands away from the summit of Cerro Punta, a currently very disturbed area where the species was once found. Additionally, three (3) new populations of *E. serpens* should be established within the Toro Negro Commonwealth Forest or a similar protected habitat (e.g., Monte Guilarte), which genetically represent the known natural populations. Since this is an epiphytic plant, the protection of forest stands that harbor *E. serpens* common host trees, (e.g., *Lyonia Rubiginosa* var. *stahluii*), is also important in order to ensure the species' viability.
  - For *P. calderonense*, the two (2) known populations within Guilarte Commonwealth Forest should be monitored and enhanced to ensure their resiliency. Also, the population within the private property at Cerrote de Peiiuelas needs to be protected through long-term conservation mechanisms (e.g., conservation easements). In order to achieve five viable populations of *P. calderonense*, two (2) new populations should be established within the Guilarte Commonwealth Forest or areas with similar habitat characteristics and forest plant species communities (e.g., Toro Negro Commonwealth Forest).
  - The two (2) current *Tectaria estremarana* populations within private properties need to be protected through long-term conservation mechanisms. Also, the population found at the Rio Abajo Commonwealth Forest should be monitored and enhanced to ensure its resiliency. Additionally, two (2) new populations should be established in properties manage for conservation within the species geographic range.
  - *Thelypteris verecunda* occurs only on three (3) private properties within the northwest region of Puerto Rico. Therefore, all three populations need to be protected through long-term conservation mechanisms, and two (2) new genetically representative populations need to be established on protected land within

its geographic range on suitable habitat for the species. • The two (2) known populations of *T. inabonensis* occur within Toro Negro Commonwealth forest. Since this is protected land, we recommend these two populations needs to be monitored and enhanced to ensure their resiliency. Additionally, we recommend the establishment of three (3) new populations also on protected land and within its geographic range. • *Thelypteris yaucoensis* occurs on two (2) private properties within Yauco, and possibly, within protected land at Los Tres Picachos. However, if these two populations are not currently protected, they need to be protected through long-term conservation mechanisms. Additionally, three (3) populations should be established within areas already managed for conservation and within the species geographic range, or sites with similar habitat characteristics and forest plant communities.

**ADDITIONAL SITE SPECIFIC RECOVERY ACTIONS**

1. Genetic material from all species should be preserved through long-term spore storage and/or propagation efforts in institutions authorized by the Service. Priority species for this action are *E. serpens*, *P. calderonenses*, and *T. inabonensis* because their taxonomy is not in question. This recovery action should be added to recovery action 33.
2. Establishing new populations outside the current range needs a monitoring and propagation protocol, and pilot studies to ensure appropriate planting sites. To be added to the recovery action 4 (41).
3. Since most agreements and conservation efforts are associated with other Service branches or partner organizations, careful planning for conservation and management needs to be developed and should include partners' education. To be added to recovery action 1 (14).
4. Implement fire and invasive plant species management and control protocols at disturbed areas. This should be added as a new action in the recovery plan (USFWS, 2019).

***Conservation Measures and Best Management Practices:***

- **RECOMMENDATIONS FOR FUTURE ACTIVITIES** In addition to recommendations in the 2017 5-year review (Service 2017), we also recognize these activities to help in the recovery of the species: 1. Conduct research to determine if *Tectaria estremarana* is a valid species, and in the case it is a hybrid establish if it is capable of reproducing or if it is sterile. 2. Continue surveying suitable habitat for the three species and updating their distribution. 3. Continue securing the species' genetic representation by banking spores to support the future establishment of new populations, or for the enhancements (augmentation) of existing populations. 4. Develop refined protocols for the species propagation from spores, and from cuttings (rhizomes or terminal buds). 5. Validate protocols for the reintroduction of these species, including the microhabitat requirements (USFWS, 2022).

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## SPECIES ACCOUNT: *Thelypteris inabonensis* (No common name)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 7/2/1993; Southeast Region (Region 4) (USFWS, 2015)

### **Physical Description**

A terrestrial fern with an erect and slender (ca 0.5 cm diameter) rhizome which is clothed at the apex with numerous dark lustrous brown, and densely setulose scales. The fronds are erect arching, up to 60 cm long. The stipes are 5 to 10 cm long and clothed with grayish, acicular hairs, and have numerous spreading scales similar to those of the rhizome. This species differs from all other Puerto Rican thelypterid ferns due to the presence of scales and acicular hairs on the rachis. The blades are narrowly elliptic, up to 55 cm long. The species has 25 to 30 pairs of sessile pinnae, rounded at the apex, and with up to seven pairs of simple veins. The tissue has numerous short, erect, acicular hairs and lacks glands. The small son, which has a densely long-ciliate indusium, are located dorsal on veins (Proctor 1989). (USFWS, 1994)

### **Taxonomy**

In the Family Thelypteridaceae, Order Polypodiales (USFWS, 1994). One common name is cordillera maiden fern (ITIS, 2017).

### **Historical Range**

Not Available

### **Current Range**

Known from two localities in the Toro Negro Commonwealth Forest: the headwaters of the Rio Inabon in Ponce and Cerro Rosa in Ciales. Forty-six plants were counted in both localities combined (Proctor 1991) (USFWS, 1994)

### **Critical Habitat Designated**

Yes;

### ***Life History***

### **Food/Nutrient Resources**

### **Reproduction Narrative**

Adult: Not available

### **Habitat Type**

Adult: Terrestrial (USFWS, 2015)

### **Habitat Vegetation or Surface Water Classification**

Adult: Wet montane forest (USFWS, 2015)

### **Geographic or Habitat Restraints or Barriers**

Adult: 3,674.5-4,121 ft (1,120-1,250 m) elevation (USFWS, 2015)

**Environmental Specificity**

Adult: Very narrow (inferred from USFWS, 2015)

**Habitat Narrative**

Adult: Thelypteris inabonensis is known from two localities, both in wet montane forests at high elevations in the Toro Negro Commonwealth Forest. Thelypteris inabonensis grows along stream banks in sierra palm (Prestoea montana) forests, and mossy forests with sierra palms in deeply-shaded humus near the summit area (3,674.5-4,121 ft (1,120-1,250 m) within the lower montane forest life zone (Ewel and Whitmore 1973) (USFWS, 2015).

***Dispersal/Migration*****Dispersal/Migration Narrative**

Adult: Not available

***Population Information and Trends*****Population Trends:**

Declining (USFWS, 1994)

**Species Trends:**

Unknown (USFWS, 2015)

**Number of Populations:**

2 (USFWS, 1994)

**Population Size:**

46 (USFWS, 1994)

**Population Narrative:**

This species was known from 46 individuals in two localities in the Toro Negro Commonwealth Forest (Proctor 1991) (USFWS 1994). The species status is unknown; the status and distribution of T. inabonensis has not been reevaluated since 1995 (USFWS 1995). (USFWS, 2015).

***Threats and Stressors***

**Stressor:** Limited distribution (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Thelypteris inabonensis is vulnerable to extinction due to low population numbers and restricted distribution. The low number of individuals and limited geographic range may also exacerbate their vulnerability to natural or anthropogenic events such as hurricanes, landslides, low genetic variation, and habitat modification, compromising the continued existence of the species (USFWS 1995) (USFWS, 2015).

**Stressor:** Genetic Variation (USFWS, 2015)

**Exposure:**



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

**Narrative:** Given the limited geographic distribution of *T. inabonensis*, it is highly likely that genetic variability is low. In rare species like this ferns, genetic variation is very important because the loss of genetic variation can reduce the ability of the species to adapt to environmental changes. In addition, it may increase the susceptibility to diseases and pests. This is highlighted by the fact that this species shows a low number of populations with a low number of individuals (USFWS, 2015)

**Stressor:** Climate change (USFWS, 2015)

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

**Narrative:** Vulnerability to climate change impacts is a function of sensitivity and exposure to those changes, and the adaptive capacity of the species (IPCC 2007, Glick et al. 2011). Therefore, shifts of vegetation communities are expected as temperatures and moisture regimes are altered by climate change. Numerous plant species in Puerto Rico survived the deforestation that occurred in the Island during the early 1930s. Some species, however, survived that deforestation and are now restricted to forests remnants. Climate change may alter or modify the microclimatic conditions of those remnants where *T. inabonensis* occurs. Under this scenario, these populations may be displaced or outcompeted by native or exotic species with wider environmental plasticity (USFWS, 2015).

**Stressor:** Stochastic events (USFWS, 2015)

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

**Narrative:** As species endemic to the Caribbean, *T. inabonensis* should be well adapted to tropical disturbance. However, as stated in the final rule, the low number of populations and individuals pose a threat to the species by making it susceptible to stochastic events such as hurricanes. Additionally, heavy rains associated with tropical storms and hurricanes in the mountains of Puerto Rico often lead to landslides, which are part of the forest dynamics. A massive landslide in areas where this species grows would not only take out the adult ferns and their offsprings, but their habitats as well. Even a small landslide would provide an opening in the vegetation that would allow other plants (native or non-native, herbaceous or woody) to become established. Moreover, the frequency and severity is expected to increase due to climate change (Hopkinson et al. 2008) (USFWS, 2015).

**Recovery****Reclassification Criteria:**

1. The known populations are placed under protective status (USFWS, 1994).
2. An agreement between the Service and the DNER concerning the protection of this species in Commonwealth forests has been developed and implemented (USFWS, 1994).
3. An agreement between the Service and Cornell University concerning the protection of *Tectaria estremeirana* on the Arecibo Radio Telescope property has been prepared and

implemented (USFWS, 1994).

4. New populations (the number of which should be determined following the appropriate studies) capable of self perpetuation have been established within protected areas (USFWS, 1994).

**Delisting Criteria:**

The amended delisting criteria for *Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* are as follows: 1. Existing populations (number populations in parentheses) of *E. Serpens* (2), *P. calderonenses* (3), *T. estremerana* (3), *T. verecunda* (3), *Tinabonensis* (2) and *T. yaucoensis* (2) show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and Factor E). 2. Establish or discover new populations (number of populations in parentheses) within the historical range of *E. serpens* (3), *T. inabonensis* (3), *T. yaucoensis* (3), *P. calderonense* (2), *T. estremerana* (2), and *T. verecunda* (2) that show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and 3. Threat reduction and management activities have been implemented to a degree that the species is viable for the foreseeable future (addresses Factor A and E) (USFWS, 2019).

**Recovery Actions:**

- Prevent further habitat loss and population decline. Protection of habitat and individual plants at known population sites should be initiated by appropriate public agencies and entities (DNER, Service. Cornell University) and private organizations (USFWS, 1994).
- Continue to gather information on the distribution and abundance of the seven endangered ferns. Additional information concerning the distribution and abundance of the species may affect future management decisions and the establishment of recovery priorities (USFWS, 1994).
- Conduct research on habitat requirements, reproductive biology, and ecology of the seven species. Basic biological information is currently needed for the seven fern species. Studies should focus on aspects of life history, methods of propagation, and evaluation of possible introduction sites. These studies may be critical in the recovery of the species (USFWS, 1994).
- Establish new populations. Areas for the establishment of new populations of the seven fern species should be selected and new populations established (USFWS, 1994).
- Refine recovery goals. As additional information on the biology, ecology, propagation, and management of these seven fern species is gathered, it will be necessary to better define, and possibly modify, recovery goals. (USFWS, 1994).
- Conduct a comprehensive status survey of these species to evaluate the abundance and distribution of *Thelypteris inabonensis* in Puerto Rico. Surveys should include both traditional and non-traditional sites (USFWS, 2015).
- Once thorough surveys are conducted, a PVA would be needed to determine the number of self-sustainable populations needed to protect and delist this species (USFWS, 2015).
- Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of this species (USFWS, 2015).

- Efforts to protect populations within privately owned lands should be initiated to reduce habitat deterioration and promote sustainable land use practices (USFWS, 2015).
  - Develop propagation techniques for *Thelypteris inabonensis* to establish new self-sustainable populations in protected areas (USFWS, 2015).
  - Considering all these factors, we recommend the following:
    - The habitat of the two (2) known populations of *E. serpens* occurring on protected land (i.e., Cerro Punta and Monte Jayuya) need to be fully assessed, and populations enhanced to ensure their resiliency. Specifically, Possley and Lange (2017), and Service biologist O. Monsegur-Rivera recommend a more comprehensive survey that covers a wider area and expands away from the summit of Cerro Punta, a currently very disturbed area where the species was once found. Additionally, three (3) new populations of *E. serpens* should be established within the Toro Negro Commonwealth Forest or a similar protected habitat (e.g., Monte Guilarte), which genetically represent the known natural populations. Since this is an epiphytic plant, the protection of forest stands that harbor *E. serpens* common host trees, (e.g., *Lyonia Rubiginosa* var. *stahlia*), is also important in order to ensure the species' viability.
    - For *P. calderonense*, the two (2) known populations within Guilarte Commonwealth Forest should be monitored and enhanced to ensure their resiliency. Also, the population within the private property at Cerrote de Peiuelas needs to be protected through long-term conservation mechanisms (e.g., conservation easements). In order to achieve five viable populations of *P. calderonenses*, two (2) new populations should be established within the Guilarte Commonwealth Forest or areas with similar habitat characteristics and forest plant species communities (e.g., Toro Negro Commonwealth Forest).
    - The two (2) current *Tectarea estremerana* populations within private properties need to be protected through long-term conservation mechanisms. Also, the population found at the Rio Abajo Commonwealth Forest should be monitored and enhanced to ensure its resiliency. Additionally, two (2) new populations should be established in properties managed for conservation within the species geographic range.
    - *Thelypteris verecunda* occurs only on three (3) private properties within the northwest region of Puerto Rico. Therefore, all three populations need to be protected through long-term conservation mechanisms, and two (2) new genetically representative populations need to be established on protected land within its geographic range on suitable habitat for the species.
    - The two (2) known populations of *T. inabonensis* occur within Toro Negro Commonwealth forest. Since this is protected land, we recommend these two populations need to be monitored and enhanced to ensure their resiliency. Additionally, we recommend the establishment of three (3) new populations also on protected land and within its geographic range.
    - *Thelypteris yaucoensis* occurs on two (2) private properties within Yauco, and possibly, within protected land at Los Tres Picachos. However, if these two populations are not currently protected, they need to be protected through long-term conservation mechanisms. Additionally, three (3) populations should be established within areas already managed for conservation and within the species geographic range, or sites with similar habitat characteristics and forest plant communities.
- ADDITIONAL SITE SPECIFIC RECOVERY ACTIONS
1. Genetic material from all species should be preserved through long-term spore storage and/or propagation efforts in institutions authorized by the Service. Priority species for this action are *E. serpens*, *P. calderonenses*, and *T. inabonensis* because their taxonomy is not in question. This recovery action should be added to recovery action 33.
  2. Establishing new populations outside the current range needs a monitoring and propagation protocol, and pilot studies to ensure appropriate planting sites. To be added to the recovery action 4 (41).
  3. Since most agreements and conservation efforts are associated with other Service branches or partner organizations,

careful planning for conservation and management needs to be developed and should include partners' education. To be added to recovery action 1 (14). 4. Implement fire and invasive plant species management and control protocols at disturbed areas. This should be added as a new action in the recovery plan (USFWS, 2019).

***Conservation Measures and Best Management Practices:***

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Conduct a comprehensive status survey of these species to evaluate the abundance and distribution of *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* in Puerto Rico. Surveys should include both traditional and non-traditional sites. 2. Once thorough surveys are conducted, a PVA would be needed to determine the number of self-sustainable populations needed to protect and delist these fern species. 3. Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of the species. 4. Efforts to protect populations within privately owned lands should be initiated to reduce habitat deterioration and promote sustainable land use practices. 5. Develop propagation techniques for *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis*, to establish new self-sustainable populations in protected areas. (USFWS, 2021)

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## SPECIES ACCOUNT: *Thelypteris pilosa* var. *alabamensis* (Alabama streak-sorus fern (=T. burksorium))

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### *Species Taxonomic and Listing Information*

**Listing Status:** Threatened; 7/8/1992; Southeast Region (Region 4) (USFWS, 2015)

### **Physical Description**

An evergreen fern with clustered fronds that develop from a short, slender rhizome. Fronds attain 3.3 cm in width and 2 cm in length but are generally shorter; the blade is sinuately lobed, with the lower pinnae separate and short stalked, becoming sessile upward. Both surfaces of the blade are covered with many slender needle-shaped hairs, especially on the axes and veins. (NatureServe, 2015)

### **Taxonomy**

Recognized as the full species *Thelypteris burksorium* by Watkins and Farrar (2002, 2005). Some Mexican populations were considered to be included in this taxon by Flora of North America (1993), but studies have shown Alabama plants to be genetically and morphologically distinct (Watkins and Farrar 2002, 2005). (NatureServe, 2015)

### **Historical Range**

The minimum historical distribution of *T. pilosa* var. *alabamensis* is assumed to include an estimated 4.25 mile segment of the Sipsey Fork, plus the stretch of stream, now inundated, between this 4.25-mile segment of river and the destroyed type locality. It is probable that the species also occurred downstream of the type locality and perhaps even on some tributaries such as Rockhouse Creek or Brushy Creek. (NatureServe, 2015)

### **Current Range**

Restricted to a 4 mile stretch of Sipsey Fork, a tributary of the Black Warrior River in Alabama. (NatureServe, 2015)

### **Critical Habitat Designated**

No;

### **Life History**

### **Food/Nutrient Resources**

### **Reproductive Strategy**

Adult: Sexual (inferred from USFWS, 2014)

### **Breeding Season**

Adult: Year round (USFWS, 1996)

### **Reproduction Narrative**

Adult: It produces spores year round (USFWS, 1996). This species has been shown to produce dwarfed viable sporophytes, but also undergoes a highly unusual form of gametophytic

proliferation, indicating that it has distinct gametophyte morphology (Watkins and Farrar 2002) (USFWS, 2014).

**Habitat Type**

Adult: Terrestrial, palustrine (NatureServe, 2015)

**Habitat Vegetation or Surface Water Classification**

Adult: Bare rock/talus/scree, forest, riparian

**Dependencies on Specific Environmental Elements**

Adult: High humidity, high substrate moisture, shade (NatureServe, 2015); diffuse light (USFWS, 1996)

**Geographic or Habitat Restraints or Barriers**

Adult: 10 - 60 ft. above river (USFWS, 1996)

**Spatial Arrangements of the Population**

Adult: Linear (see threats)

**Environmental Specificity**

Adult: Very narrow (NatureServe, 2015)

**Habitat Narrative**

Adult: Moist sandstone surfaces, usually under rock overhangs or on exposed cliff faces, and either directly above a stream or nearby. Sites vary from completely shaded to partially sunny. Moisture comes from water seeping over the sandstone from up-slope runoff and, for sites directly above the stream, from water vapor. Associates include various bryophytes and climbing hydrangea (*Decumaria barbara*). Grows on shaded moist ledges of sandstone which forms massive bluffs. Plants usually are scattered in moss and liverwort mats in the crevices of the bluffs. Shade is provided by a bluff and ravine forest of hemlock, various cove-type hardwoods including *Quercus rubra*, *Q. alba*, ash, tulip poplar, elm, maple, *Betula lenta*, etc. Habitat for this rare fern is maintained by a combination of high humidity, high substrate moisture, and shade, the humidity provided by evaporation from the stream, the substrate moisture by seepage over the sandstone and bryophyte mats, the shade by overhanging branches of trees which also tend to trap the moist air. Danger to the fern could come from logging of the bluff woodlands, this admitting too much light, reducing humidity, thus generally contributing to a drying out and destruction of the habitat (Kral 1983). The environmental specificity is very narrow (NatureServe, 2015). It occurs in a 4.25 mile segment of Sipsey Fork, a tributary of the Black Warrior River. Plants root in crevices and on rough rock surfaces of Pottsville sandstone bluffs along the river. Plants usually occur hanging from sandstone overhangs (rockhouses) and recessed walls, on ledges beneath overhangs, and on exposed cliff faces. A few occurrences of the plant are in moist seepage areas on exposed vertical rock faces. Fern microhabitat is maintained by surface moisture seepage over the sandstone where the fern is growing as well as high humidity. Usually a minimum of 10 ft. above the water level. Requires diffuse light. The herbaceous community is considered the hemlock-hardwood forest association ( a bluff ravine forest dominated by hemlock and other cove hardwood species). It occurs 10 to 60 ft. above the river (USFWS, 1996). All known Alabama occurrences of the Alabama streak-sorus fern are found on Pottsville sandstone, where plants grow in crevices and

rough surfaces on the roofs and floors of sandstone rockhouses formed along these cliffs (Watkins and Farrar 2002) (USFWS, 2014).

### ***Dispersal/Migration***

#### **Dispersal/Migration Narrative**

Adult: Not available

### ***Population Information and Trends***

#### **Population Trends:**

Unknown (NatureServe, 2015)

#### **Species Trends:**

Stable (USFWS, 2014)

#### **Number of Populations:**

~14 distinct occurrences (USFWS, 2021)

#### **Population Size:**

8,100-9,475 (USFWS, 2021)

#### **Population Narrative:**

At the time of listing, this species was only known from 17 distinct occurrences along a single 4 mile reach of the Sipsey Fork within the Bankhead National Forest, in Winston County, Alabama. Two additional occurrences were documented since the time of listing, however the species continues to only be found in one drainage. Five of the original occurrences were revisited in 2014, 2015 and 2016 without relocating plants, however, the range of the species remains the same. Due to the close proximity of the existing sites to each other, all of the sites have been regrouped into two populations according to Alabama Natural Heritage Networks definition of what constitutes an individual population (Al Schotz, Alabama Natural Heritage Program, February 12, 2021, pers. comm.). Most of this reach of Sipsey Fork where the populations occur is protected under Forest Service management, but some of the stream bank is in private ownership not subject to Forest Service management guidelines or take provisions of the ESA. Most of the occurrences are located in Bankhead National Forest; however, at least four sites and a portion of a fifth site, are located on private inholdings. Data gathered through the ALNHP study, determined the estimate of *T. burksiorum* to be between 8,100 and 9,475 plants distributed among 14 remaining occurrences (Godwin and Schotz 2017). No discernable trends were apparent in number of plants among the four monitoring plots sampled during the project from 2013-2017 (USFWS, 2021)

### ***Threats and Stressors***

**Stressor:** Habitat destruction and modification (USFWS, 2014)

**Exposure:**

**Response:**

**Consequence:**



**Narrative:** This species continues to be threatened by future road or dam construction projects, and rises in the downstream reservoir; however, long term changes in reservoir pool levels are not possible without significant structural modifications to Lewis Smith Dam. Logging above the occupied sites could adversely affect the microhabitat needed by the species by removing the canopy cover and thereby reducing the shaded conditions and humidity levels. Additionally, the forest is currently faced with an infestation of hemlock wooly adelgid, an invasive insect that seriously damages hemlock ecosystems. Losing hemlock trees in the vicinity of the ferns locations could reduce shaded conditions and high humidity levels needed by the species. The species also continues to be threatened by recreational use of the river corridor, loss of forest cover from fire, timbering on the slopes overlooking the river, or loss of hemlock trees leading to changes in shade, humidity, and moisture gradients in fern habitat, and development of private inholdings (USFWS, 2014).

**Stressor:** Stochastic events (USFWS, 2014)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** The greatest threat to the Alabama streak-sorus fern is its vulnerability due to its extremely restricted range and the relatively small number of plants comprising its population. Because the fern is located in a linear stretch of the Sipsey Fork, a single, natural or human-induced catastrophic disturbance could eliminate or seriously reduce the size of the existing populations. Natural threats, such as severe flooding or drought, or erosional collapse of sandstone overhangs, could dramatically reduce the number of plants throughout the range, or completely eliminate some sites (USFWS, 2014).

## ***Recovery***

### **Reclassification Criteria:**

Not available

### **Delisting Criteria:**

The population on the Sipsey Fork, and at least two other populations in different drainages, are protected and determined to be viable (USFWS, 2014).

### **Recovery Actions:**

- Protect populations (USFWS, 1996).
- Search for new occurrences (USFWS, 1996).
- Maintain plants in cultivation (USFWS, 1996).
- Develop management plans (USFWS, 1996).
- Monitor populations (USFWS, 1996).
- Establish additional populations, if found to be necessary (USFWS, 1996).
- Initiate at least semi-annual long-term monitoring on sites located on the Sipsey Fork (USFWS, 2014).
- Attempt to locate additional populations in nearby drainages (USFWS, 2014).
- Work to obtain protection for sites on privately-owned lands (USFWS, 2014).
- Research life history parameters and propagation techniques (USFWS, 2014).

- Continue to work cooperatively with the Bankhead National Forest to evaluate potential impacts to the plant from recreational use and implement corrective measures (USFWS, 2014).
- Enter into an MOU to work toward the recovery of this plant through the development of conservation measures (USFWS, 2014).

***Conservation Measures and Best Management Practices:***

- RECOMMENDATIONS FOR FUTURE ACTIONS • Initiate at least semi-annual long-term monitoring on sites located on the Sipsey Fork. • Attempt to locate additional populations in nearby drainages. • Work to obtain protection for sites on privately-owned lands. • Research life history parameters and propagation techniques. • Continue to work cooperatively with the Bankhead National Forest to evaluate potential impacts to the plant from recreational use and implement corrective measures. • Enter into an MOU to work toward the recovery of this plant through the development of conservation measures. • Periodic monitoring is encouraged to assess population trends, specifically in relation to climate change. Because of the species' narrow ecological niche, ongoing research is recommended to assess the impacts of climate change on the plants themselves and their habitat. (USFWS, 2021)

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**SPECIES ACCOUNT: *Thelypteris verecunda* (No common name)**

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***Species Taxonomic and Listing Information***

**Listing Status:** Endangered; 7/2/1993; Southeast Region (Region 4) (USFWS, 2015)

**Physical Description**

A terrestrial fern with creeping. 2- to 3-mm thick rhizomes. The apex bears brown scales, 1 mm long and 0.5 mm wide. The species has dimorphic fronds which are clothed throughout with star shaped hairs, and numerous much longer simple hairs. The stipes or stalks are 1 to 1.5 cm long and 0.4 to 0.5 mm thick. The sterile blades are oblongate, 2.5 to 4 cm long, 1.5 to 2 cm broad, truncate at the base, and rounded at the broadly-lobed apex. The sterile blades have 2 to 4 pairs of short-stalked, round-oblong. 0.8 to 1 cm long and 0.4 to 0.6 cm wide, entire pinnae with simple veins. The fertile blades are 2 linear to attenuate, 13 to 15 cm long, 1.2 to 1.8 cm broad, truncate at the base, and the rachis bears a minute proliferous bud below the apex. These blades have 15 to 20 pairs of mostly rounded-oblong to oval, 0.3 to 0.4 cm wide, short-stalked, entire pinnae. The small and erect son, which have a minute indusium, are located in an inframedial position, and bear a tuft of long, white, simple hair (Proctor 1989). (USFWS, 1994)

**Taxonomy**

Not Available

**Historical Range**

Not Available

**Current Range**

It is found at three localities: Charcas Ward in Quebradillas, Bayaney Ward in Hatillo, and Cidral Ward in the municipality of San Sebastian. In Bayaney Ward about 20 plants are known (Proctor 1991). All of these localities are privately owned lands. (USFWS, 1994)

**Critical Habitat Designated**

Yes;

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

Adult: Not available

**Habitat Type**

Adult: Terrestrial (EPA, 2016)

**Habitat Vegetation or Surface Water Classification**

Adult: Subtropical moist forest (EPA, 2016)

**Habitat Narrative**

Adult: Karst or limestone region of northwestern Puerto Rico. Occurs within semi-evergreen seasonal forests of the subtropical moist forest life zone (USFWS, 1994).

### ***Dispersal/Migration***

### ***Population Information and Trends***

#### **Population Trends:**

Not available

#### **Species Trends:**

Unknown (USFWS, 2015)

#### **Number of Populations:**

3 (USFWS, 1994)

#### **Population Narrative:**

The species is unknown; the status and distribution of *T. verecunda* has not been reevaluated since 1995 (USFWS 1995) (USFWS, 2015). *Thelypteris verecunda* is found at three localities (USFWS, 1994).

### ***Threats and Stressors***

**Stressor:** Habitat destruction and modification (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** The Puerto Rico Planning Board classified Bayaney ward in the municipality of Hatillo and Cidral ward in the municipality of San Sebastián as Districts of General Agriculture (AG). This classification allows agricultural development such as planting of agricultural products and cattle grazing. On the other hand, the Puerto Rico Planning Board classified Charcas ward in the municipality of Quebradillas as a District of Conservation Resource 1 (CR-1, the most restrictive for development, precluding tourist and residential development activities). This classification though, allows agricultural (e.g. cattle grazing) and rural developments. Therefore, clearing or development in these areas could have adverse effects on *T. verecunda* (USFWS, 2015).

**Stressor:** Limited distribution (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** *T. verecunda* is vulnerable to extinction due to low population numbers and restricted distribution. The low number of individuals and limited geographic range may also exacerbate its vulnerability to natural or anthropogenic events such as hurricanes, landslides, low genetic variation, and habitat modification, compromising the continued existence of this species (USFWS1995). In rare species like this fern, genetic variation is very important because the loss of genetic variation can reduce the ability of these species to adapt to environmental changes. In addition, it may increase the susceptibility to diseases and pests. This is highlighted by the fact that this species shows a low number of populations with a low number of individuals (USFWS,

2015).

**Stressor:** Stochastic events (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** As a species endemic to the Caribbean, *T. verecunda* should be well adapted to tropical disturbance. However, as stated in the final rule, the low number of populations and individuals pose a threat to the species by making it susceptible to stochastic events such as hurricanes. Additionally, heavy rains associated with tropical storms and hurricanes in the mountains of Puerto Rico often lead to landslides, which are part of the forest dynamics. A massive landslide in areas where this species grows would not only take out the adult ferns and their offsprings, but their habitats as well. Even a small landslide would provide an opening in the vegetation that would allow other plants (native or non-native, herbaceous or woody) to become established. Moreover, the frequency and severity is expected to increase due to climate change (Hopkinson et al. 2008 (USFWS, 2015).

**Stressor:** Climate change (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Vulnerability to climate change impacts is a function of sensitivity and exposure to those changes, and the adaptive capacity of the species (IPCC 2007, Glick et al. 2011). Therefore, shifts of vegetation communities are expected as temperatures and moisture regimes are altered by climate change. Numerous plant species in Puerto Rico survived the deforestation that occurred in the Island during the early 1930s. Some species, however, survived that deforestation and are now restricted to forests remnants. Climate change may alter or modify the microclimatic conditions of those remnants where *T. verecunda* occurs. Under this scenario, these populations may be displaced or outcompeted by native or exotic species with wider environmental plasticity (USFWS, 2015).

## **Recovery**

### **Reclassification Criteria:**

1. The known populations are placed under protective status (USFWS, 2015).
2. An agreement between the Service and the Puerto Rico Department of Natural Resources (PRDNER) concerning the protection of the three fern species in Commonwealth Forests has been developed and implemented (USFWS, 2015).
3. New populations (the number of which should be determined by appropriate studies) capable of self-perpetuation have been established within protected areas (USFWS, 2013).

### **Delisting Criteria:**

The amended delisting criteria for *Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* are as follows: 1. Existing populations (number populations in parentheses) of *E. Serpens* (2), *P. calderonenses* (3), *T. estremerana* (3), *T. verecunda* (3), *Tinabonensis* (2) and *T. yaucoensis* (2)

show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and Factor E). 2. Establish or discover new populations (number of populations in parentheses) within the historical range of *E. serpens* (3), *T. inabonensis* (3), *T. yaucoensis* (3), *P. calderonense* (2), *T. estremerana* (2), and *T. verecunda* (2) that show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and 3. Threat reduction and management activities have been implemented to a degree that the species is viable for the foreseeable future (addresses Factor A and E) (USFWS, 2019).

#### **Recovery Actions:**

- Prevent further habitat loss and population decline (USFWS, 1994).
- Continue to gather information on the distribution and abundance of the species (USFWS, 1994).
- Conduct research on habitat requirements, reproductive biology, and ecology of the seven species (USFWS, 1994).
- Establish new populations (USFWS, 1994).
- Refine recovery goals (USFWS, 1994).
- Conduct a comprehensive status survey of these species to evaluate the abundance and distribution of *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* in Puerto Rico. Surveys should include both traditional and non-traditional sites (USFWS, 2015).
- Once thorough surveys are conducted, a PVA would be needed to determine the number of self-sustainable populations needed to protect and delist these fern species (USFWS, 2015).
- Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of the species (USFWS, 2015).
- Efforts to protect populations within privately owned lands should be initiated to reduce habitat deterioration and promote sustainable land use practices (USFWS, 2015).
- Develop propagation techniques for *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis*, to establish new self-sustainable populations in protected areas (USFWS, 2015).
- Considering all these factors, we recommend the following:
  - The habitat of the two (2) known populations of *E. serpens* occurring on protected land (i.e., Cerro Punta and Monte Jayuya) need to be fully assessed, and populations enhanced to ensure their resiliency. Specifically, Possley and Lange (2017), and Service biologist O. Monsegur-Rivera recommend a more comprehensive survey that covers a wider area and expands away from the summit of Cerro Punta, a currently very disturbed area where the species was once found. Additionally, three (3) new populations of *E. serpens* should be established within the Toro Negro Commonwealth Forest or a similar protected habitat (e.g., Monte Guilarte), which genetically represent the known natural populations. Since this is an epiphytic plant, the protection of forest stands that harbor *E. serpens* common host trees, (e.g., *Lyonia Rubiginosa* var. *stahlia*), is also important in order to ensure the species' viability.
  - For *P. calderonense*, the two (2) known populations within Guilarte Commonwealth Forest should be monitored and enhanced to ensure their resiliency. Also, the population within the private property at Cerrote de Peiuelas needs to be protected through long-term conservation mechanisms (e.g., conservation easements). In order to achieve five viable populations of *P. calderonenses*, two (2) new populations should be established within the

Guilarte Commonwealth Forest or areas with similar habitat characteristics and forest plant species communities (e.g., Toro Negro Commonwealth Forest). • The two (2) current *Tectarea estremerana* populations within private properties need to be protected through long-term conservation mechanisms. Also, the population found at the Rio Abajo Commonwealth Forest should be monitored and enhanced to ensure its resiliency. Additionally, two (2) new populations should be established in properties managed for conservation within the species geographic range. • *Thelypteris verecunda* occurs only on three (3) private properties within the northwest region of Puerto Rico. Therefore, all three populations need to be protected through long-term conservation mechanisms, and two (2) new genetically representative populations need to be established on protected land within its geographic range on suitable habitat for the species. • The two (2) known populations of *T. inabonensis* occur within Toro Negro Commonwealth forest. Since this is protected land, we recommend these two populations need to be monitored and enhanced to ensure their resiliency. Additionally, we recommend the establishment of three (3) new populations also on protected land and within its geographic range. • *Thelypteris yaucoensis* occurs on two (2) private properties within Yauco, and possibly, within protected land at Los Tres Picachos. However, if these two populations are not currently protected, they need to be protected through long-term conservation mechanisms. Additionally, three (3) populations should be established within areas already managed for conservation and within the species geographic range, or sites with similar habitat characteristics and forest plant communities.

**ADDITIONAL SITE SPECIFIC RECOVERY ACTIONS**

1. Genetic material from all species should be preserved through long-term spore storage and/or propagation efforts in institutions authorized by the Service. Priority species for this action are *E. serpens*, *P. calderonenses*, and *T. inabonensis* because their taxonomy is not in question. This recovery action should be added to recovery action 33.
2. Establishing new populations outside the current range needs a monitoring and propagation protocol, and pilot studies to ensure appropriate planting sites. To be added to the recovery action 4 (41).
3. Since most agreements and conservation efforts are associated with other Service branches or partner organizations, careful planning for conservation and management needs to be developed and should include partners' education. To be added to recovery action 1 (14).
4. Implement fire and invasive plant species management and control protocols at disturbed areas. This should be added as a new action in the recovery plan (USFWS, 2019).

***Conservation Measures and Best Management Practices:***

- **RECOMMENDATIONS FOR FUTURE ACTIONS**

  1. Conduct a comprehensive status survey of these species to evaluate the abundance and distribution of *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* in Puerto Rico. Surveys should include both traditional and non-traditional sites.
  2. Once thorough surveys are conducted, a PVA would be needed to determine the number of self-sustainable populations needed to protect and delist these fern species.
  3. Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of the species.
  4. Efforts to protect populations within privately owned lands should be initiated to reduce habitat deterioration and promote sustainable land use practices.
  5. Develop propagation techniques for *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis*, to establish new self-sustainable populations in protected areas. (USFWS, 2021)

**References**



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## SPECIES ACCOUNT: *Thelypteris yaucoensis* (No common name)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 7/2/1993; Southeast Region (Region 4) (USFWS, 2015)

#### **Physical Description**

A terrestrial fern with an erect, 0.5-mm-thick rhizome, which is bearded at the apex with a tuft of brown, narrowly to broadly lance-attenuate. 5 to 8 mm long scales. The few fronds are 44 to 52 cm long and have lustrous light brown, glabrous, 18- to 22-cm long stipes. The blades are narrowly deltate to oblong. 25 to 31 cm long, 10 to 14 cm broad, acuminate at the apex and truncate at the base. The rachis, costae and costules are more or less stellate-puberulous on both sides. This fern has 13 to 15 pairs of alternate, irregularly linear-oblong pinnae. The pinnae are mostly simple, with 5 to 6 pairs of veins and are all free except for the lowest pairs which are more or less joined. This fern has inframedial to medial sori, which are ciliated with minute forked and 3-branched hairs, and have small indusium often hidden by the sporangia (Proctor 1989). (USFWS, 1994)

#### **Taxonomy**

Not Available

#### **Historical Range**

Not Available

#### **Current Range**

*Thelypteris yaucoensis* is known from Los Tres Picachos in the municipality of Ciales, and from two other private properties in the municipality of Yauco: Pico Rodadero, Sierra Alta and at Rubias Wards. Current population estimates for each location is unclear, however, Proctor (1991) reported 65 individuals for all three sites. Nonetheless, Possley and Lange (2016) re-discovered the species at Pico Rodadero and documented about 59 plants of what seemed to be *T. yaucoensis*. Morphological similarities with *T. sclerophylla* pose taxonomical questions on the identity of *T. yaucoensis* (Possley and Lange 2016, 2017). Currently, tissue samples are being analyzed at the University of Florida (Possley and Lange 2017). The other two localities, Los Tres Picachos and Rubias Ward, have not been visited since 1991 and, therefore, their current status remains unknown. Furthermore, it is unclear if the population of *T. yaucoensis* at Los Tres Picachos lies within the boundaries of the area managed for conservation by the Puerto Rico Department of Natural and Environmental Resources. *Thelypteris inabonensis* is only known from two localities within the Toro Negro Commonwealth Forest: headwaters of Rio Inabón, and Cerro Rosa, where 34 and 12 plants were reported by Proctor (1991), respectively (USFWS 2010). Neither of these populations have been visited since 1991 and, therefore, their current status is unknown. These ferns are known to occur on medium to high elevation mountains (USFWS 2010, USFWS 2015) mostly on sites that exhibit mature vegetation with dense or closed canopies, which often promotes specific microhabitat conditions that are essential for their establishment (e.g., shaded conditions, moisture, humus and mossy substrate, high humidity level and moderate temperatures (USFWS 2010, USFWS 2015)). Therefore, habitat destruction or modification is one of the most conspicuous threats that these fern species may face, not only by individuals directly impacted, but often by changes in microhabitat, which also may favor establishment of exotic plant species (USFWS, 2019).

**Critical Habitat Designated**

Yes;

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

Adult: Not available

**Habitat Type**

Adult: Terrestrial (EPA, 2016)

**Habitat Vegetation or Surface Water Classification**

Adult: Subtropical moist forest (EPA, 2016)

**Geographic or Habitat Restraints or Barriers**

Adult: ~2788 to 3936 ft. elevation (EPA, 2016)

**Environmental Specificity**

Adult: Narrow (inferred from EPA, 2016)

**Habitat Narrative**

Adult: This species grows in humus on steep, shaded rocky banks and ledges in the central mountains with the municipalities of Yauco and Ciales in subtropical moist forest life zone. It occurs between 2788 and 3936 ft. in elevation (EPA, 2016).

***Dispersal/Migration*****Dispersal/Migration Narrative**

Adult: This species relies on abiotic dispersal mechanisms (EPA, 2016).

***Population Information and Trends*****Population Trends:**

Not available

**Species Trends:**

Unknown (USFWS, 2015)

**Number of Populations:**

3 (USFWS, 1994)

**Population Size:**

65 (USFWS, 1994)

**Population Narrative:**

The specie status is unknown; The status and distribution of *T. yaucoensis* has not been reevaluated since 1995 (USFWS 1995) (USFWS, 2015). *T. yaucoensis* is known from 3 sites, from which approximately 65 individuals have been estimated (Proctor 1991) (USFWS, 1994).

### ***Threats and Stressors***

**Stressor:** Habitat destruction and modification (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** *Thelypteris yaucoensis* is known to occur in Rubias Ward and the summit area of Pico Rodadero, Sierra Alta Ward in Yauco. Currently, Rubias Ward is known for its agricultural practices, the majority of the private lands located at this Ward have active coffee plantations. Although Pico Rodadero is a privately owned land, people have access to this mountain and often go hiking and drive ATVs throughout the property. Thus, the species can be affected by these practices due to habitat destruction (e.g., cattle grazing, agricultural practices, human induced fire). The low number of known individuals (i.e., 65 individuals within these three locations), and the restricted distribution of the species, makes it more susceptible to habitat modification, which could result in the elimination of the populations (USFWS, 2015).

**Stressor:** Limited distribution (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** *T. yaucoensis* is vulnerable to extinction due to low population numbers and restricted distribution. The low number of individuals and limited geographic range may also exacerbate its vulnerability to natural or anthropogenic events such as hurricanes, landslides, low genetic variation, and habitat modification, compromising the continued existence of this species (USFWS1995) (USFWS, 2015).

**Stressor:** Genetic variation (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Given the limited geographic distribution of *T. yaucoensis*, it is highly likely that its genetic variability is low. In rare species like this fern, genetic variation is very important because the loss of genetic variation can reduce the ability of these species to adapt to environmental changes. In addition, it may increase the susceptibility to diseases and pests. This is highlighted by the fact that these three species show a low number of populations with a low number of individuals (USFWS, 2015).

**Stressor:** Stochastic events (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** As a species endemic to the Caribbean, *T. yaucoensis* should be well adapted to tropical disturbance. However, as stated in the final rule, the low number of populations and individuals pose a threat to the species by making it susceptible to stochastic events such as

hurricanes. Additionally, heavy rains associated with tropical storms and hurricanes in the mountains of Puerto Rico often lead to landslides, which are part of the forest dynamics. A massive landslide in areas where this species grows would not only take out the adult ferns and their offsprings, but their habitats as well. Even a small landslide would provide an opening in the vegetation that would allow other plants (native or non-native, herbaceous or woody) to become established. Moreover, the frequency and severity is expected to increase due to climate change (Hopkinson et al. 2008) (USFWS, 2015).

**Stressor:** Climate change (USFWS, 2015)

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Vulnerability to climate change impacts is a function of sensitivity and exposure to those changes, and the adaptive capacity of the species (IPCC 2007, Glick et al. 2011). Therefore, shifts of vegetation communities are expected as temperatures and moisture regimes are altered by climate change. Numerous plant species in Puerto Rico survived the deforestation that occurred in the Island during the early 1930s. Some species, however, survived that deforestation and are now restricted to forests remnants. Climate change may alter or modify the microclimatic conditions of those remnants where *T. yaucoensis* occurs. Under this scenario, these populations may be displaced or outcompeted by native or exotic species with wider environmental plasticity (USFWS, 2015).

### ***Recovery***

#### **Reclassification Criteria:**

1. The known populations are placed under protective status (USFWS, 2015).
2. An agreement between the Service and the Puerto Rico Department of Natural Resources (PRDNER) concerning the protection of the three fern species in Commonwealth Forests has been developed and implemented (USFWS, 2015).
3. New populations (the number of which should be determined by appropriate studies) capable of self-perpetuation have been established within protected areas (USFWS, 2015).

#### **Delisting Criteria:**

The amended delisting criteria for *Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* are as follows: 1. Existing populations (number populations in parentheses) of *E. Serpens* (2), *P. calderonenses* (3), *T. estremerana* (3), *T. verecunda* (3), *Tinabonensis* (2) and *T. yaucoensis* (2) show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and Factor E). 2. Establish or discover new populations (number of populations in parentheses) within the historical range of *E. serpens* (3), *T. inabonensis* (3), *T. yaucoensis* (3), *P. calderonense* (2), *T. estremerana* (2), and *T. verecunda* (2) that show a stable or increasing trend, evidenced by natural recruitment and multiple age classes, and populations extending onto private lands are protected via a conservation mechanism (addresses Factor A and 3. Threat reduction and management activities have been implemented to a degree that the species is viable for the foreseeable future (addresses Factor A and E) (USFWS, 2019).

**Recovery Actions:**

- Prevent further habitat loss and population decline (USFWS, 1994).
- Continue to gather information on the distribution and abundance of the seven endangered ferns (USFWS, 1994).
- Conduct research on habitat requirements, reproductive biology, and ecology of the seven species (USFWS, 1994).
- Establish new populations (USFWS, 1994).
- Refine recovery goals (USFWS, 1994).
- Conduct a comprehensive status survey of these species to evaluate the abundance and distribution of *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* in Puerto Rico. Surveys should include both traditional and non-traditional sites (USFWS, 2015).
- Once thorough surveys are conducted, a PVA would be needed to determine the number of self-sustainable populations needed to protect and delist these fern species (USFWS, 2015).
- Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of the species (USFWS, 2015).
- Efforts to protect populations within privately owned lands should be initiated to reduce habitat deterioration and promote sustainable land use practices (USFWS, 2015).
- Develop propagation techniques for *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis*, to establish new self-sustainable populations in protected areas (USFWS, 2015).
- Considering all these factors, we recommend the following:
  - The habitat of the two (2) known populations of *E. serpens* occurring on protected land (i.e., Cerro Punta and Monte Jayuya) need to be fully assessed, and populations enhanced to ensure their resiliency. Specifically, Possley and Lange (2017), and Service biologist O. Monsegur-Rivera recommend a more comprehensive survey that covers a wider area and expands away from the summit of Cerro Punta, a currently very disturbed area where the species was once found. Additionally, three (3) new populations of *E. serpens* should be established within the Toro Negro Commonwealth Forest or a similar protected habitat (e.g., Monte Guilarte), which genetically represent the known natural populations. Since this is an epiphytic plant, the protection of forest stands that harbor *E. serpens* common host trees, (e.g., *Lyonia Rubiginosa* var. *stahlia*), is also important in order to ensure the species' viability.
  - For *P. calderonense*, the two (2) known populations within Guilarte Commonwealth Forest should be monitored and enhanced to ensure their resiliency. Also, the population within the private property at Cerrote de Peiuelas needs to be protected through long-term conservation mechanisms (e.g., conservation easements). In order to achieve five viable populations of *P. calderonense*s, two (2) new populations should be established within the Guilarte Commonwealth Forest or areas with similar habitat characteristics and forest plant species communities (e.g., Toro Negro Commonwealth Forest).
  - The two (2) current *Tectarea estremarana* populations within private properties need to be protected through long-term conservation mechanisms. Also, the population found at the Rio Abajo Commonwealth Forest should be monitored and enhanced to ensure its resiliency. Additionally, two (2) new populations should be established in properties manage for conservation within the species geographic range.
  - *Thelypteris verecunda* occurs only on three (3) private properties within the northwest region of Puerto Rico. Therefore, all three populations need to be protected through long-term conservation mechanisms, and two (2)

new genetically representative populations need to be established on protected land within its geographic range on suitable habitat for the species. • The two (2) known populations of *T. inabonensis* occur within Toro Negro Commonwealth forest. Since this is protected land, we recommend these two populations need to be monitored and enhanced to ensure their resiliency. Additionally, we recommend the establishment of three (3) new populations also on protected land and within its geographic range. • *Thelypteris yaucoensis* occurs on two (2) private properties within Yauco, and possibly, within protected land at Los Tres Picachos. However, if these two populations are not currently protected, they need to be protected through long-term conservation mechanisms. Additionally, three (3) populations should be established within areas already managed for conservation and within the species geographic range, or sites with similar habitat characteristics and forest plant communities.

**ADDITIONAL SITE SPECIFIC RECOVERY ACTIONS**

1. Genetic material from all species should be preserved through long-term spore storage and/or propagation efforts in institutions authorized by the Service. Priority species for this action are *E. serpens*, *P. calderonense*, and *T. inabonensis* because their taxonomy is not in question. This recovery action should be added to recovery action 33.
2. Establishing new populations outside the current range needs a monitoring and propagation protocol, and pilot studies to ensure appropriate planting sites. To be added to the recovery action 4 (41).
3. Since most agreements and conservation efforts are associated with other Service branches or partner organizations, careful planning for conservation and management needs to be developed and should include partners' education. To be added to recovery action 1 (14).
4. Implement fire and invasive plant species management and control protocols at disturbed areas. This should be added as a new action in the recovery plan (USFWS, 2019).

***Conservation Measures and Best Management Practices:***

- **RECOMMENDATIONS FOR FUTURE ACTIONS**

  1. Conduct a comprehensive status survey of these species to evaluate the abundance and distribution of *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* in Puerto Rico. Surveys should include both traditional and non-traditional sites.
  2. Once thorough surveys are conducted, a PVA would be needed to determine the number of self-sustainable populations needed to protect and delist these fern species.
  3. Conduct comprehensive studies on habitat requirements, phenology, and recruitment success of the species.
  4. Efforts to protect populations within privately owned lands should be initiated to reduce habitat deterioration and promote sustainable land use practices.
  5. Develop propagation techniques for *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis*, to establish new self-sustainable populations in protected areas. (USFWS, 2021)

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## SPECIES ACCOUNT: *Trichomanes punctatum* ssp. *floridanum* (Florida bristle fern)

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### *Species Taxonomic and Listing Information*

**Listing Status:** Endangered; 11/05/2015; Southeast Region (R4) (USFWS, 2016)

### Physical Description

The Florida bristle fern is a very small, mat-forming fern, superficially resembling some liverwort species. Wunderlin and Hansen (2000, pp. 153-154) described it as "Stem long-creeping, mat forming, the trichomes (hairlike or bristlelike outgrowth) brownish black, of 2 types, 2-celled glandular and elongate rhizoidlike ones; roots absent. Leaves separated, the petiole 0.1-2 centimeters (cm) long, usually shorter than the blade, pubescent above and below with trichomes like those of the stem but shorter, with stellate (star-shaped) trichomes few and distal on the winged upper part, the blade flabellate (fan-shaped), round, narrowly oblanceolate to nearly linear, entire or irregularly lobed at the apex, 0.5-2 cm long, 0.2-1.1 cm wide, the midrib wanting or less than ½ the blade length, the apex rounded to obtuse, the base narrowly cuneate (wedge-shaped), the margin entire to irregularly and flabellately lobed, lobes oblong and blunt to obscurely deltoid, frequently resembling proliferous outgrowths distally, with marginal black stellate trichomes, with 2-celled glandular trichomes on the veins, false veins few, the true veins not enlarged at their apex. Involucres (a cup-shaped structure which houses the spore-bearing organs) 1.5-2 millimeters (mm) long, 1-6 at the blade apex, immersed for ½ or more of their length to fully so, the lips distinct from the blade tissue, inconspicuously dark-margined, the receptacle included or exerted to less than about ½ the involucre length."

### Taxonomy

The genus *Trichomanes* is mostly tropical, with about 300 species. A few species grow in temperate regions. When Florida bristle fern was first discovered in Miami-Dade County it was referred to as *T. sphenoides* Kunze (Eaton 1906, p. 460; Small 1913, p. 4). Underwood (1906, p. 201) treated Miami-Dade plants as *Didymoglossum sphenoides* (Kunze) Presl. John Kunkel Small later determined the plants in Miami-Dade County to be *T. punctatum* (Small 1918a, p. 6; Small 1918b, p. 4; Small 1931, p. 35). After it was found in Sumter County in 1936, John Kunkel Small referred the Miami-Dade plants to *T. punctatum* and the Sumter plants to *T. sphenoides* (Small 1938, pp. 48-50). This treatment was followed by Wherry (1964, p. 232). The current taxonomy of *Trichomanes punctatum* is the result of monographic revision of *Trichomanes* sections *Didymoglossum* and *Microgonium* by Wessels Boer (1962, pp. 300-301). We have carefully reviewed the available taxonomic information to reach the conclusion that the subspecies is a valid taxon.

### Historical Range

The historical range of Florida bristle fern included southern (Miami-Dade County) and central (Sumter County) Florida. In Miami-Dade County it occurred historically in at least 12 hammocks (Castellow, Cox, Fuchs, Hattie Bauer, Meissner, Modello area, Nixon-Lewis, Ross, Royal Palm, Shields, Silver Palm, Snapper Creek area) (Gann et al. 2002, pp. 552-554). The range extended from Royal Palm Hammock (now in Everglades National Park [ENP]) at its southern limit, north to at least Snapper Creek, and possibly further north into the Miami area (Gann et al. 2002, pp. 552-554). This is a range of at least 45 kilometers (km) (28 miles [mi]).

**Current Range**

There are currently five, and possibly six, extant occurrences of Florida bristle fern (Gann et al. 2002, pp. 552-554), four in Miami-Dade County and two in Sumter County (Table 1). The Sumter County occurrences are approximately 400 km (249 mi) north of those in Miami-Dade County. In Miami-Dade County, Florida bristle fern is known from Meissner Hammock<sup>1</sup> in two solution holes (K. Bradley, pers. comm. 2009), from Fuchs Hammock Preserve<sup>2</sup> in three solution holes, and from Castellow Hammock Park<sup>3</sup> in two large solution holes and several smaller holes and rocky outcroppings (J. Possley, pers. comm. 2008). Fuchs and Meissner Hammocks are immediately adjacent to each other, and Castellow Hammock Park is 10.5 km (6.5 mi) to the northeast. During 2011, eight small patches of Florida bristle fern were re-discovered at Hattie Bauer Hammock<sup>4</sup>. Seven of the these patches occurred within a single solution hole, the eighth patch was found a few meters away from the hole J. Possley (pers. comm. 2011). Hattie Bauer Hammock is 2.5 miles south of Castellow Hammock and approximately 5 miles northeast of Fuchs and Meissner Hammocks. In Sumter County, it is known from one colony in the Withlacoochee State Forest's Jumper Creek Tract<sup>5</sup>, north of Wahoo. Another occurrence consisting of two colonies on private land just south of the State Forest<sup>6</sup> may be extirpated.

**Critical Habitat Designated**

Yes; 1/23/2023.

**Legal Description**

We, the U.S. Fish and Wildlife Service (Service), designate critical habitat for the Florida bristle fern (*Trichomanes punctatum* ssp. *floridanum*) under the Endangered Species Act of 1973 (Act), as amended. In total, approximately 1,698 hectares (ha) (4,195 acres (ac)) fall within 10 units of critical habitat in Miami-Dade and Sumter Counties, Florida. This rule extends the Act's protections to the Florida bristle fern's designated critical habitat.

**Critical Habitat Designation**

Critical habitat units are depicted for Miami-Dade and Sumter Counties.

**Primary Constituent Elements/Physical or Biological Features**

Within these areas, the physical or biological features essential to the conservation of Florida bristle fern consist of the following components:

- (A) Upland hardwood forest hammock habitats of sufficient quality and size to sustain the necessary microclimate and life processes for Florida bristle fern.
- (B) Exposed substrate derived from oolitic limestone, Ocala limestone, or exposed limestone boulders, which provide anchoring and nutritional requirements.
- (C) Constantly humid microhabitat consisting of dense canopy cover, moisture, stable high temperature, and stable monthly average humidity of 90 percent or higher, with intact hydrology within hammocks and the surrounding and adjacent wetland communities.
- (D) Dense canopy cover of surrounding native vegetation that consists of the upland hardwood forest hammock habitats and provides shade, shelter, and moisture.

(E) Suitable microhabitat conditions, hydrology, and connectivity that can support Florida bristle fern's growth, distribution, and population expansion (including rhizomal growth, spore dispersal, and sporophyte and gametophyte growth and survival).

(F) Plant community of predominantly native vegetation that is minimally disturbed or free from human-related disturbance, with either no competitive nonnative, invasive plant species, or such species in quantities low enough to have minimal effect on Florida bristle fern.

### ***Life History***

#### **Food/Nutrient Resources**

#### **Reproductive Strategy**

Adult: Sexual and asexual

#### **Breeding Season**

Adult: Spores have been recorded in October (J. Possley, pers. comm. 2007), but plants probably produce spores during much of the summer wet season.

#### **Key Resources Needed for Breeding**

Adult: Unknown

#### **Reproduction Narrative**

Adult: Little is known about the life history of this taxon, or for members of the genus in general. Like all ferns, Florida bristle fern has two life history stages, a gametophyte stage and a sporophyte stage. All populations that have been reported have been in the sporophyte stage. The initial stage, after a spore germinates, is the gametophyte stage. The gametophyte contains separate sperm and egg producing structures. In the presence of water or moisture, sperm reach the eggs for fertilization. Fertilized eggs, under the proper conditions, develop into sporophytes – the typical form most ferns are observed in. The sporophytes produce spores which in turn can germinate to produce new gametophytes (Nelson 2000, pp. 17-19). Reproduction may also occur in two other ways. Plants may reproduce by division, when rhizomes break, forming clones of the parent plant. They may also reproduce with the production of gemmae, propagules produced by gametophytes, which can grow into new gametophytes of the same genotype (Hill 2003, p. 12). Spores have been recorded in October (J. Possley, pers. comm. 2007), but plants probably produce spores during much of the summer wet season. During the dry season, sporophytes have been observed to desiccate, and probably do not produce spores. For Florida bristle fern, the reproductive requirements, such as moisture levels, needed for each stage of its life history are unknown. Data are needed on longevity, growth rates, recruitment rates, dispersal methods, and genetic variation.

#### **Habitat Type**

Adult: Tropical hardwood forest

#### **Environmental Specificity**

Adult: Narrow (inferred from USFWS, 2012)

#### **Habitat Narrative**

Adult: Florida bristle fern is always associated with shaded limestone outcrops. Plants usually grow on bare limestone, but are occasionally found on tree roots growing on limestone. In Miami-Dade County, it has been found exclusively in oolitic (composed of minute rounded concretions resembling fish eggs) limestone solution holes and rocky outcrops in rockland hammocks. Solution holes are formed by dissolution of subsurface limestone followed by a collapse above (Snyder et al. 1990, p. 236). Solution holes vary in size, from shallow holes less than 0.5 meter (m) (1.6 feet [ft]) deep to those that cover over 100 m<sup>2</sup> (1,076 ft<sup>2</sup>) and are several meters deep. The bottoms of most solution holes are filled with deep organic soils. Deeper solution holes penetrate the water table and have (at least historically) standing water for part of the year. Humidity levels are higher in and around the solution holes because of standing water and moisture retained in the organic soils. The canopy cover is typically very dense where Florida bristle fern occurs, and consists of a mix of temperate and tropical hardwood trees including lancewood (*Ocotea coriacea*), pigeon plum (*Coccoloba diversifolia*), live oak (*Quercus virginiana*), paradise tree (*Simarouba glauca*), strangler fig (*Ficus aurea*), and mastic (*Sideroxylon foetidissimum*) (K. Bradley, pers. comm. 2007). Many tropical, epipetric plant species are associated with solution holes in rockland hammocks. Soils at the Miami-Dade County sites are classified as Matecumbe Muck (<http://www.fgdl.org/>). In Sumter County, the plants occur in a mesic/hydric hammock on limestone boulders 1 - 2 m (3.3 - 6.6 ft) tall, under a canopy of live oak, cabbage palm (*Sabal palmetto*), and American hornbeam (*Carpinus caroliniana*) (C. Werner, pers. comm. 2007). Florida bristle fern grows on boulders with tall, horizontal faces with other rare fern species (e.g., hemlock spleenwort [*Asplenium cristatum*], and widespread polypody [*Pecluma dispersa*]). The hammocks where it has been found are surrounded by a mosaic of wetlands. Soils at the Sumter County station are classified as Mabel Fine Sand, bouldery subsurface (<http://www.fgdl.org/>).

***Dispersal/Migration*****Motility/Mobility**

Adult: Sessile

**Dispersal**

Adult: Unknown

**Dispersal/Migration Narrative**

Adult: No information

***Population Information and Trends*****Population Trends:**

declining

**Species Trends:**

declining (NatureServe 2010, pp.1-2)

**Number of Populations:**

6 (USFWS, 2023)

**Population Size:**

<1000 plants

**Population Narrative:**

Because Florida bristle fern grows in dense mats and is rhizomatous, it is difficult, if not impossible, to accurately count individual plants. This difficulty has been encountered in other *Trichomanes* species, such as Appalachian bristle fern (*Trichomanes boscianum*) (Hill 2003, p. 11). In Miami-Dade County the taxon occurs at four sites in eight solution holes and several smaller holes and rocky outcroppings (J. Possley, pers. comm. 2008, 2011). Possley has estimated that individual colonies cover from 30 cm<sup>2</sup> (4.7 inches<sup>2</sup> [in]) to a maximum of 400 cm<sup>2</sup> (62 in<sup>2</sup>) on the walls of solution holes. The total area covered by the colonies at the eight solution holes is roughly 1620 cm<sup>2</sup> [251.1 in<sup>2</sup>]. There are probably less than 500 total plants, and many plants may be genetically identical, since new plants can arise from broken rhizomes (Possley, pers. comm. 2011). In Sumter County, the single small colony grows on five or six boulders and covers approximately 0.3 m<sup>2</sup> (3.0 ft<sup>2</sup>) (C. Werner, pers. comm. 2007). There are probably fewer than 1,000 total plants in existence, but this may be a large overestimate of the actual number (K. Bradley, pers. comm. 2007). 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<sup>2</sup>) (129 square feet [ft<sup>2</sup>]) (Table 2) (USFWS, 2023).

**Threats and Stressors**

**Stressor:** Regional drainage

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Impacts from regional drainage in Miami-Dade County are severe and currently occurring. Regional drainage in remaining habitat has probably been a stressor that has contributed to extirpations and population declines (Nauman 1986, p. 182). Resulting drops in ambient humidity in the taxon's habitat may limit reproduction and health of populations over the long-term. Such changes in humidity may cause extirpations or make plants more vulnerable to other stressors (e.g., periodic long-term droughts, hurricanes).

**Stressor:** Agricultural conversion and development

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Agricultural conversion and development are currently occurring in Sumter County, placing any undocumented occurrences and suitable habitat at risk. Since a full survey of suitable habitats for Florida bristle fern has never been conducted in Sumter County, we cannot determine the extent of losses of this species due to habitat destruction and modification nor the magnitude and immediacy of current threats.

**Stressor:** Invasive nonnative plants

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Invasive exotic plants are also a threat, but may be reduced on public lands due to active programs by Miami-Dade County and the State.

**Stressor:** Climate change

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Climatic changes, including sea level rise, are future, long-term threats that are expected to impact habitat and ultimately reduce the extent of available habitat in Miami-Dade County.

**Stressor:** Stochastic events

**Exposure:**

**Response:**

**Consequence:**

**Narrative:** Because there are few occurrences, populations contain few plants, and genetic variability is low, the species is inherently at risk due to stochastic events (Matthies et al. 2004, pp. 481-488). Stochastic events are expected to exacerbate the impacts of regional drainage and subsequent drops in humidity and cause extirpations. Droughts, tropical storms, and hurricanes are threats. Since few occurrences remain, the entire taxon is threatened with extinction during these events.

### ***Recovery***

**Reclassification Criteria:**

Recovery Priority Number: 6 (USFWS, 2018)

**Recovery Actions:**

- Control invasive nonnative plants.
- Reintroduce to historic locations through outplantings.
- Augment existing occurrences through outplantings.
- Collect, cultivate, and maintain of genetic stock ex situ for reintroduction and augmentation.
- Refine ex situ cultivation methods.
- Conduct status surveys at all known, current, and historic locations where suitable habitat remains.
- Restore canopy cover (with shade cloth if needed) over existing colonies after hurricanes or other events cause loss of canopy.
- Promote a higher regional water table on the Miami Rock Ridge.
- Protect habitats from public use.
- Explore the feasibility of pumping water into solution holes that support rare ferns to increase water and humidity levels.
- Explore the potential benefits of watering colonies during extended drought periods.

- Search for new occurrences and all potential suitable habitat in and around Sumter County.
- Search for occurrences in historically occupied areas in Miami-Dade County
- Conduct long-term monitoring of all occurrences.
- Establish a monitoring program at Withlacoochee State Forest.
- Initiate life-history and genetic studies, specifically on longevity, growth rates, recruitment rates, reproductive requirements, dispersal methods, and genetic variation.
- Assess the extent to which fungus may be a threat to the species in the wild.
- Initial recovery actions for the Florida bristle fern will primarily focus on protection of the existing known populations and their habitat and monitoring of these sites. The Florida bristle fern requires multiple (redundancy), self-sustaining (resiliency) populations distributed across its gradient of genetic and ecological diversity (representation). At this time, we do not fully understand these parameters. Therefore, recovery actions to further define those parameters include:
  - Conduct or continue surveys for new populations of the Florida bristle fern.
  - Continue to monitor known Florida bristle fern plants and habitat conditions. This includes monitoring a) the health and numbers of populations, b) microhabitat conditions of humidity (moisture), temperature, hydrology, and substrate, and c) surrounding forest vegetation where sinkholes and limestone outcroppings occur (canopy cover, shade and protection).
  - Prevent damage and loss of existing hammock habitats (primarily from invasive vegetation); maintain the health and vegetative diversity of mixed wetland tropical hardwood system.
  - Conduct or continue research to address a) methods of propagation and reintroduction, and b) spore dispersal and conditions needed for reproduction (such as adequate moisture levels).
  - Enhance populations through captive propagation and reintroduction.
  - Identify project types and locations that may need special attention (timber; loss of surrounding forest causing edge effect to hammock microclimate).
  - Continue to work cooperatively with federal, state, and local government agencies, universities, private landowners, the public, and other recovery partners to restore and protect forested hammock habitat and the Florida bristle fern metapopulations.
  - Perform outreach and education on the hammock environment and the Florida bristle fern (USFWS, 2018).

***Conservation Measures and Best Management Practices:***

- 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 x 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. x Work with private landowners surrounding occupied hammocks (especially bordering Hattie Bauer Hammock) to treat invasive vegetation and maintain native plant diversity. x Conduct reintroductions at historically occupied hammocks where habitat remains (see Table 3). Monitoring/Research Activities x 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. x Conduct research to develop best practices for spore collection and propagation.

**References**

USFWS 2012. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for *Trichomanes punctatum* ssp. *floridanum* (Florida Bristle Fern)

2012

Southeast Region

21 p.. USFWS 2014. Endangered and Threatened Wildlife and Plants

Endangered Species Status for *Trichomanes punctatum* ssp. *floridanum* (Florida Bristle Fern)

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