Elaphoglossum serpens
(no common name)
Polystichum calderonense
(no common name)
Tectaria estremerana
(no common name)

5-Year Review:
Summary and Evaluation

Tectaria estremerana
Photo by USFWS

U.S. Fish and Wildlife Service
Southeast Region
Caribbean Ecological Services Field Office
Boquerón, Puerto Rico

5-YEAR REVIEW
Elaphoglossum serpens (no common name)
Polystichum calderonense (no common name)
Tectaria estremerana (no common name)

I. GENERAL INFORMATION

A. Methodology used to complete the review: On September 27, 2006, the Service published a notice in the *Federal Register* (71 FR 56545) announcing the initiation of the 5-year reviews of *Elaphoglossum serpens, Polystichum calderonense, Tectaria estremerana* (ferns) and requesting new information concerning the biology and status of the species. A 60-day comment period was also opened. No comments were received from the public during this period.

This review was prepared by the lead recovery biologist for the species to summarize new information that the Service has on these species. We conducted a literature search on the species; no new information was found. We also requested information and comment from botanical experts familiar with these species (see List of Peer Reviewers). No comments from the peer reviewers were received.

B. Reviewers
Lead Region: Kelly Bibb, Southeast Region, (404) 679-7132.

Lead Field Office: Marelisa Rivera, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico, (787) 851-7297, extension 231.

C. Background

1. FR Notice citation announcing initiation of these reviews:
September 27, 2006; 71 FR 56545

2. Species Status: 2009 Recovery Data Call
Uncertain. No recent surveys have been conducted for these species and the current population numbers are not known. Their rarity and limited distribution makes these species vulnerable to habitat modification. Surveys to update the status of the species and determine the overall status of these species are needed.

3. Recovery Achieved: 1 (1= 0-25% recovery objectives achieved)

4. Listing History
Original Listing for all 3 Ferns
FR notice: 58 FR 32308
Date listed: June 9, 1993

Entity listed: Species
Classification: Endangered

5. Review History:

The Final Rule (58 FR 32308) determining *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* to be endangered pursuant to the Endangered Species Act (Act) of 1973, as amended, was published on June 9, 1993.

The Recovery Plan, a multi-species plan, included seven endemic fern species (*Adiantum vivesii*, *Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis*) was approved and signed on January 17, 1995 (Service 1994).

The Recovery Data Call for *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* states that the status of these three species is uncertain. Last population surveys were conducted in 1991 for *Elaphoglossum serpens* and *Polystichum calderonense*, and in 1995 for *Tectaria estremerana*. No recent surveys have been conducted for these species to verify their abundance and distribution.

Recovery Data Call: 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, and 1998

6. Species' Recovery Priority Number at start of review (48 FR 43098):

At the time of listing, *Elaphoglossum serpens* and *Polystichum calderonense* were considered as species with high degree of threat and a low recovery potential (RPN=5). *E. serpens* was known from only one locality where 22 individual plants occurred on the mossy trunks of only six trees (Proctor 1991, p.83). On the other hand, fifty-seven individuals of *P. calderonense* were found in two localities: La Silla de Calderón in Monte Guilarte, Adjuntas (45 individuals including juveniles), and Cerrote in Peñuelas (12 plants). According to Proctor (1991, p.153), both sites are vulnerable to indiscriminate cutting and fires.

Tectaria estremerana was recognized as a species with moderate degree of threat and high recovery potential (RPN=8). This species was reported from only one locality in the limestone hills of Puerto Rico: the vicinity of the Arecibo Radio Telescope (Proctor 1989, p.171). Later observations indicated that the species did occur in the Río Abajo Commonwealth Forest and in the Municipality of Florida.

7. Recovery Plan:
Name of plan: Puerto Rican Endangered Ferns Recovery Plan
Date issued: January 17, 1995.

II. REVIEW ANALYSIS

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

These ferns are plants and, therefore, not covered by the DPS policy. The other DPS questions will not be addressed further in this review.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? The multi-species recovery plan which includes *Elaphoglossum serpens*, *Polystichum calderonense,* and *Tectaria estremerana* established reclassification from endangered to threatened (downlisting) as the recovery objective. The plan established four downlisting criteria for all seven species. The Plan did not establish recovery criteria for delisting.

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes. We have not received additional information about the habitat and biology of these three species since the Plan was approved.

b. Are all the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats? No (see the Five Factor analysis below). We need to understand more about the abundance and distribution of theses species to modify the original Plan's criteria.

3. List the recovery criteria as they appear in the recovery plan. and discuss how each criterion has or has not been met, citing information.

The plan established the following downlisting criteria for seven fern species including *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana*:

1. The known populations are placed under protective status.

2. An agreement within the Service and the Puerto Rico Department of Natural and Environmental Resources (DNER) concerning the

protection of the three of the seven species in Commonwealth forests has been developed and implemented.

3. An agreement within the Service and Cornell University concerning the protection of *Tectaria estremerana* on the Arecibo Radio Telescope has been prepared and implemented.

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

Criterion 1 has not been initiated. *Polystichum calderonense* and *Tectaria estremerana* are known to occur in privately-owned lands, and efforts to protect the areas have not been initiated.

Criterion 2 has been met. The Service and DNER have a signed Cooperative Agreement under Section 6 of the ESA to establish vigorous endangered species programs in Puerto Rico. The species are listed by DNER. Commonwealth laws and regulations appropriately protect the species and their habitats within public forests.

Criterion 3 and Criterion 4 have not been initiated.

C. Updated Information and Current Species Status

1. Biology and Habitat

The Recovery Plan reported one locality for *Elaphoglossum serpens* with approximately 22 individual plants in Cerro Punta in Jayuya. The species was described as an epiphytic fern found in a patch of a montane dwarf forest, on the mossy trunks of only six trees (Proctor 1991, p.83). *Tectaria estremerana*, described as a terrestrial woody fern found in the karst region of northern Puerto Rico, was known from only one site in Arecibo in which 23 individuals were found (Proctor 1989, p.171). Observations and collections reported in 1992 and 1995 indicate that *T. estremerana* occur in two additional locations (Florida and Utuado). Fifty-seven individual plants of *Polystichum calderonense* are reported in two areas (Peñuelas and Guilarte Coomonwealth Forests). This species was described as an evergreen terrestrial fern found in two localities in the volcanic-origin mountains in the central and south central Puerto Rico (USFWS 1994, pp7-8).

a. Is there relevant new information regarding the species' abundance, population trends, demographic features, or demographic trends? No**.**

b. Is there relevant new information regarding the species' genetics, genetic variation, or trends in genetic variation? No

c. Is there relevant new information regarding taxonomic classification or changes in nomenclature? No

d. Is there relevant new information regarding the species' spatial distribution, trends in spatial distribution, or historic range? No

e. Is there relevant new information addressing habitat or ecosystem conditions? No.

2. Five Factor Analysis

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

In the final rule, destruction and modification of habitat was established as a significant factor that may affect the number and distribution of four endemic ferns including *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* (US Fish and Wildlife Service 1993, p.32309). According to the rule, *E. serpens* was extirpated from the site in Monte Jayuya where it was first reported due to the construction of a communication facility. It was later reported by Proctor (1991, p.81) that most plants found on the summit of Cerro Punta were destroyed by the construction of telecommunication towers and only 22 survived the encroachment caused by this activity. Although the area where *Elaphoglossum serpens* historical population occurs is located within a Commonwealth forest, permit requests to build new communication facilities or expand currently existing ones are prevalent. The Puerto Rico Department of Natural and Environmental Resources is recommending monopole, multiple-use towers, as a habitat conservation measure, whenever possible instead of constructing new towers and antennae (Gerardo Hernández, PRDNER, pers. comm., 2007)

The Recovery Plan identifies destruction and modification of habitat as the most significant factors affecting the numbers and distribution of these three endemic ferns. *Polystichum calderonense* and *Elaphoglossum serpens* are also threatened by unplanned forest management practices conducted in Commonwealth forests.

Polystichum calderonense occurs on both privately- and publicly-owned lands. This species is present in the Guilarte Commonwealth

Forest and it was stated in the final rule that *P. calderonense* may be affected by forested management practices. 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.

Tectaria estremerana was only known from one site within the property of the Arecibo Radio Telescope managed by Cornell University. The plan establishes that the population is located about 200 meters south of the telescope which makes the species vulnerable to any expansion or development of the facilities. Funds are limited for these facilities and their operation. In case these facilities are abandoned, new land uses that could possibly affect *T. estremerana* may be proposed in the future.

Based on the above, destruction, modification, and curtailment of *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* habitat or range continues to be a threat to these species. Due to the restricted distributions and relatively low population numbers of these three species, the immediacy of this threat is considered high.

(b) Overutilization for commercial, recreational, scientific or educational purposes:

These species are protected by local laws and regulations (see Factor d below) which prohibit collection of listed plant species. Therefore, overutilization for commercial, recreational, scientific, or educational purposes is no longer considered a threat for these three species.

(c) Disease or predation:

At the present time, the Service is not aware that disease or predation constitutes a limiting factor for these three fern species.

(d) Inadequacy of existing regulatory mechanisms:

In 1999, the Commonwealth of Puerto Rico approved Law #241 known as the “Nueva Ley de Vida Silvestre de Puerto Rico” (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species within its jurisdiction, regulate permits, regulate hunting activities, and regulate exotic species, among others. In 2004, the Puerto Rico Department of Natural and Environmental Resources approved the “Reglamento para regir el manejo de las Especies Vulnerables y en

Peligro de Extinción en el Estado Libre Asociado de Puerto Rico" (Regulation 6766: To regulate the management of threatened and endangered species in Puerto Rico). *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* are included in the list of protected species and designated as "critically endangered" under regulation 6766. This classification is given to a species which "faces an extremely high risk of extinction in the immediate future." Under this regulation (Article 2.06) prohibits collecting, cutting, removing, among other activities, listed animals and plants within the jurisdiction of Puerto Rico.

Besides the above regulations, the Department as well as the Service considers these fern species when reviewing development projects and conducting section 7 consultation within the known range of the species or within their potential habitat.

Based on the presence of Federal and Commonwealth laws and regulations protecting *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana*, and the absence of evidence supporting lack of enforcement of regulations to protect this species or governmental measures to prevent destruction of its habitat, we believe that inadequacy of existing regulatory mechanisms should no longer be considered a threat to these three species.

(e) Other natural or manmade factors affecting its continued existence:

Limited distributions of *Elaphoglossum serpens*, *Polystichum calderonense* and *Tectaria estremerana* is an important factor affecting these species. In addition, small population numbers make them particularly vulnerable to extinction due to the lack of genetic variation necessary to evolve and respond to natural changes. The best available information collected for *E. serpens* showed only 22 individuals all occurring on the mossy trunks of 6 trees of *Lyonia rubiginosa* var. *stahlii* (present in one of its few known localities) in Cerro Punta, Jayuya. Twenty-three individuals of *T. estremerana* were found at its only known location in the limestone hills of northern Puerto Rico (Arecibo) and *Polystichum calderonense* was known from only two localities: Monte Guilarte Commonwealth forest in Adjuntas, and Cerrote in Peñuelas. Proctor (1991) reported that *P. calderonense* could also be affected by fires, and Hurricane Hugo in 1989 badly damaged the only known population of *Elaphoglossum serpens* in Cerro Punta.

Despite the occurrence of several major storms, due to the lack of information or evidence indicating major storms or fires will decimate

the existing populations of these three fern species, we believe that the magnitude of threat from other natural and manmade factors to *Elaphoglossum serpens, Polystichum calderonense* and *Tectaria estremerana* is low and the immediacy of threat is non-imminent.

3. Synthesis

Elaphoglossum serpens is an epiphytic fern presently known from the Cerro Punta in the municipality of Jayuya. Only 22 plants, all occurring on the mossy trunks of only six trees of *Lyonia rubiginosa* var. *stahlii* which has few known localities (Proctor 1991), are known. This species is found in the summit area in a patch of montane dwarf forest at an elevation of about 1,300 meters within the Toro Negro Commonwealth Forest.

Polystichum calderonense is an evergreen terrestrial fern only known from two localities. Forty-five individual plants (including juveniles) are known from the summit of "La Silla de Calderón" in the Monte Guilarte Commonwealth Forest (Proctor 1989). Additionally, 12 individuals found by Proctor (1991) in Cerrote Peñuelas in the municipality of Peñuelas.

Tectaria estremerana is a woody terrestrial fern which was found at Esperanza ward in Arecibo, in the vicinity of the Arecibo Radio Telescope (Proctor 1991). This species was only known from this site where approximately 23 individual plants were found. This species was later collected in the Río Abajo Commonwealth Forest in Arecibo and in a sinkhole near an old quarry at Florida Adentro Ward in the municipality of Florida.

According to the five factor analysis performed for this review, these three species are still threatened by Factor A (destruction, modification, and curtailment of habitat or range) and Factor E (other natural or manmade factors affecting its continued existence). Construction of new communication facilities or expansion of the existing ones may affect the only known population of *Elaphoglossum serpens* in Cerro Punta, Jayuya. *Polystichum calderonense* occurs on both privately- and publicly-owned lands and may be affected by forest management practices while occurring in publicly-owned lands and by industrial and/or residential development when present in private lands. At the same time, the only population known of *Tectaria estremerana* is located about only 200 meters south of the telescope which makes the species vulnerable to any expansion or development of the facilities.

Low numbers of individuals of each species are known from few localities. Since no new information is available to the Service showing that either the distribution or abundance of these species has improved, the limited distribution of *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* continues to be an important factor affecting these species. Therefore, we believe these three ferns continue to meet the definition of endangered under the Endangered Species Act.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

a. Evaluate abundance and distribution of *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* 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 these three fern populations (wild, naturally-reproducing populations large enough to maintain sufficient genetic variation, and evolve and respond to natural habitat changes).

b. 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.

c. 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.

d. Propagation techniques should be developed for the species to establish new self sustainable populations in protected areas.

V. REFERENCES

Proctor, George R. 1989. Ferns of Puerto Rico and the Virgin Islands. The New York Botanical Gardens Press, Bronx, New York. 389 pp.

Proctor, George R. 1991. Puerto Rican Plant Species of Special Concern: Status and Recommedations. Publicación Científica Miscelánea No.2. Departamento de Recursos Naturales. San Juan, Puerto Rico 196 pp.

U.S. Fish and Wildlife Service. 1994. Puerto Rican Endangered Ferns Recovery Plan. Atlanta, Georgia. 23pp.

List of Peer Reviewers

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Elaphoglossum serpens* (no common name)
Polystichum calderonense (no common name)
Tectaria estremerana (no common name)

Current Classification for the 3 Ferns: Endangered

Recommendation resulting from the 5-Year Review

___X__ No change is needed

Review Conducted By ____Ana Roman and Marelisa Rivera_____

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve Edwin Muñiz Date 14 January 2010

REGIONAL OFFICE APPROVAL:

Acting
Lead Regional Director, Fish and Wildlife Service

Approve Aaron L Valenta Date 1-15-2010

The Regional Director must sign all 5-year reviews, unless the authority has been delegated by the Regional Director to the Field Supervisor.

FY 2017 Approval follows:

FY 2017 APPROVAL*

Lead Field Supervisor, Fish and Wildlife Service

Approve Edwin Muñiz Date 7/27/2017

*In 2014, Southeast Region Field Supervisors have been delegated authority to approve 5-year reviews that do not recommend a status change.
Field Supervisor signature on this document reflects:
1. ____ We have no new information, received no new public comments, and the original five factor analysis remains an accurate reflection of the species current status.
2. _X__ We have obtained a small amount of new information that we have summarized in Addendum 1, received no new public comments, and the original five factor analysis remains an accurate reflection of the species current status.

U.S FISH AND WILDLIFE SEVICE
5-YEAR REVIEW of *Elaphoglossum serpens*,
Polystichum calderonense* and *Tectaria estremerana

Addendum 1. Summary of new information obtained since the 2010 5 Year Review.

Updated information on Distribution and Abundance

In 2014, a cooperative agreement among the U.S. Fish and Wildlife Service (Service) and Fairchild Tropical Botanic Garden, Inc. (Fairchild) was established to implement recovery actions for six federally listed plant species (*Eugenia woodburyana, Aristida chaseae, Aristida portoricensis, Lyonia truncata var proctorii, Vernonia proctorii* and *Stahlia monosperma*) in the southwest corner of Puerto Rico; and develop sound propagation protocols and a seed bank for four of the six species in collaboration with the Service and the University of Puerto Rico for eventual enhancement of natural populations.

Although *Elaphoglossum serpens, Polystichum calderonense* and *Tectaria estremerana* were not part of the cooperative agreement, Fairchild took the initiative to start working with the propagation and spores banking of five federally listed ferns species that occurs on the Central Mountain Cordillera of Puerto Rico and the moist northern Karst Region including these three fern species. In 2016, the cooperative agreement was modified to continue these efforts, and included a pilot reintroduction project focused on *Polystichum calderonense*. The goal of these actions is to prevent the extinction of these narrow-range endemics by enhancing their populations, to safeguard their genetic diversity, and to store seeds long-term.

Between November 2014 and November 2016, Fairchild conducted several assessments/surveys for these three endangered ferns. These assessments included: mapping, evaluation of population health, collection of tissue samples of each taxon and closely related congeners for genetic analysis, collection of spores if available, and shipment of spores to long-term cryogenic storage at the USDA Plant and Animal Genetic Resources Preservation Unit (PAGRP) in Fort Collins, CO (Possley and Lange, 2016). The assessment also included spore germination trials and initiating an ex situ plant collection at Fairchild for display and/or research. Table 1 present the number of individuals observed in natural populations found during the surveys.

Elaphoglossum serpens - In January 2016, Fairchild and USFWS staff conducted a survey near the summit of Cerro Punta (see red triangle in Figure 1), where *E. serpens* was found by Roy Woodbury in 1989. During this survey at Cerro Punta they did not find *E. serpens* (Possley and Lange, 2016). Further efforts to survey habitat at Cerro Punta were conducted on February 2017 and were also negative (O. Monsegur, pers. comm. 2017).

Polystichum calderonense (Figure 2) - In November 2014, Fairchild staff visited Guilarte Forest near the summit of Silla de Calderón (Figure 2) where they counted 12 individuals of *P. calderonense*, one of which was small and not yet reproductive (Possley and Lange, 2016). This finding suggests evidence of natural recruitment with this population. In February 2016, Fairchild in conjunction with staff from the University of Puerto Rico in Mayagüez and Service's

staff revisited the Silla de Calderón population of *P. calderonense*. This time they counted 15 individuals, of which two were tiny new plantlets (Possley and Lange, 2016). They observed that many of the ferns were very dry with multiple brown fronds. Spore collection was performed for this species. Fairchild showed that spores from *P. calderonense* have >70% viability in laboratory tests, and that the species propagates easily from proliferous buds that form on the frond tips of mature plants. As of November 2016, the current inventory of *P. calderonense* at Fairchild includes 130 individuals from three genetic lines (Possley and Lange, 2016). In addition to the 130 sporophytes, they maintain hundreds of gametophytes in propagation boxes, which could generate hundreds of additional plants (Possley and Lange, 2016). To date, they have stored spores from 4 genetic lines of *P. calderonense* from Silla de Calderón in long-term cryogenic storage at PAGRP; and are currently cultivating healthy ex situ collections (130 sporophytes + numerous gametophytes) at Fairchild Tropical Botanic Garden, Inc. (Possley and Lange, 2016).

Tectaria estremerana - In November 2014, Fairchild staff visited previously documented and suspected location of *T. estremerana* with staff from Service within the Rio Abajo Forest (Figure 2) in a sinkhole and the base of several haystack hills near Highway 10, near Finca Opiola, and near "Comunidad of El Jobo". During the survey, the group found just 3 individuals of *T. estremerana* in the Highway 10 location, and a single individual close to Finca Opiola (Possley and Lange, 2016). All plants found had fertile fronds, but one was underdeveloped and the others appeared to have already released most of their spores (Possley and Lange, 2016). Fairchild's staff did not recover enough spores to store any *T. estremerana* in long-term cryogenic storage at PAGRP. In January 2016, Fairchild revisited the Highway 10 population in Rio Abajo Forest to collect further samples, where they located the same 3 individuals found in 2014 (Possley and Lange, 2016). These two sites are in addition to previously reported individuals in the Arecibo area.

Table 1. Total number of individuals observed in natural populations through the survey.

Species	Location	Number of individuals	Source
Elaphoglossum serpens	Toro Negro Forest (Cerro Punta)	0	Possley and Lange (2016)
Polystichum calderonense	Guilarte Forest (Silla de Calderón)	15	Possley and Lange (2016)
Tectaria estremerana	Rio Abajo Forest (near Highway 10)	3	Possley and Lange (2016)
	Rio Abajo Forest (Near Finca Opiola)	1	Possley and Lange (2016)

Figure 1. General distribution of *Elaphoglossum serpens*, *Polystichum calderonense* and *Tectaria estremerana* (Service 2017).

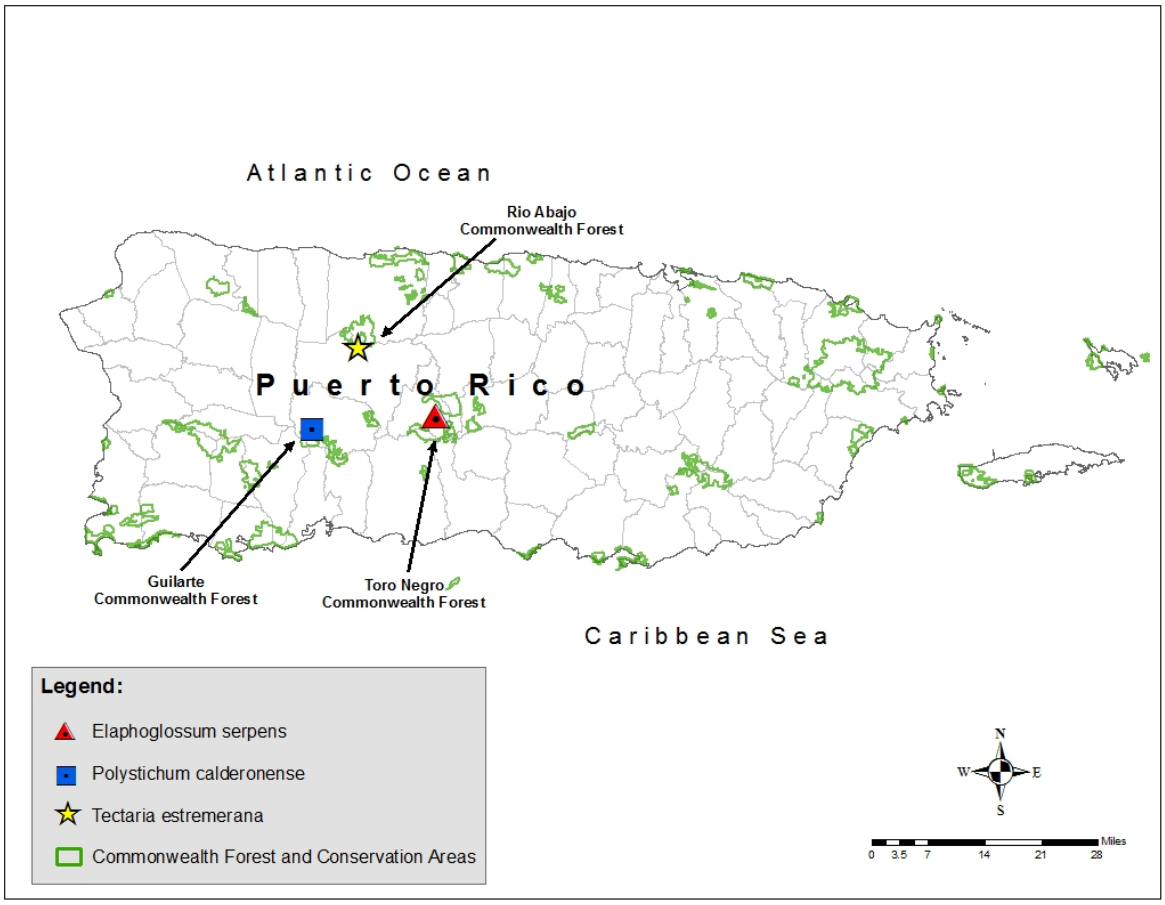

Figure 2. *Polystichum calderonense* at Guilarte Commonwealth Forest.

a) Fertile frond with sporangi.

b) Proliferous bud at the tip of frond.

Updated information on Threats

As part of this review, the Service assessed the five factor analysis, and we continue to believe that *E. serpens*, *P. calderonense* and *T. estremerana*, are still threatened by Factor A (destruction, modification, and curtailment of habitat or range) and Factor E (other natural or manmade factors affecting its continued existence). During visits to locations where *E. serpens, P. calderonense and T. estremerana* occur, Service biologists and Fairchild staff continue to observe threats that affects the species which are discussed below.

In Cerro Punta, the habitat where *E. serpens* has been documented is affected by activities associated with the maintenance of telecommunication towers (Possley and Lange, 2016). In Silla de Calderon, we observed that recreational activities (i.e. impacts from hikers, such as terrain disturbance, increase trampling of individuals and human induced fire) are affecting the habitat of *P. calderonense*. In the Río Abajo Forest, the construction of Highway 10 has resulted in disturbed areas where non-native species dominate and are a few hundred yards from the largest known population of *T. estremerana*, which contains only three individuals (Possley and Lange, 2016). Climate change is an additional threat to consider, as *E. serpens* and *P. calderonense* favors high-elevation elfin forest near the summit of mountains, and increasing global temperatures may reduce or eliminate this type of habitat (Possley and Lange, 2016). Due to the restricted distributions and relatively low population numbers of these three species, we considered that their resiliency, redundancy and representation are low since any stochastic event may decimate these species.

During Fiscal Year 2017, the Service provided technical assistance to the National Science Foundation (NCF) as part of the Environmental Impact Statement (EIS) for the proposed changes to the Arecibo Observatory operations. The Service recommended extensive surveys of *Tectaria estremerana* within the habitat that may be affected by the proposed alternatives (USFWS, 2016). During the surveys, the species was not found within the surveyed areas, thus, we agreed with the not likely to adversely affect determination for the species.

Synthesis

Since the previous 5-year review of *E. serpens*, *P. calderonense* and *T. estremerana*, Fairchild in collaboration with the University of Puerto Rico in Mayagüez, Puerto Rico Department of Natural and Environmental Resources and the Service conducted site visits to known populations to assess the species and collect spores. The site visits were conducted between November 2014 and November 2016. *E. serpens* was not found during the survey at Cerro Punta (Possley and Lange, 2016), where it was last verified as present over two decades ago by Proctor (USFWS 2010; Possley and Lange, 2016). At Guilarte Forest near the summit of Silla de Calderón, Fairchild counted 15 individuals of *P. calderonense*, and at Río Abajo Forest they located 3 individuals of *T. estremerana* between Highway 10 and Finca Opiola (Possley and Lange, 2016). The assessment also included spore germination trials and initiation of an ex situ plant collection at Fairchild Tropical Botanic Garden for display and/or research. Fairchild showed that spores from *P. calderonense* have >70% viability in laboratory tests, and that the species propagates easily from proliferous buds that form on the frond tips of mature plants. These three species have a restricted distributions and low population numbers; and are still

threatened by Factor A (destruction, modification, and curtailment of habitat or range) and Factor E (other natural or manmade factors affecting its continued existence). The Endangered Species Act defines as endangered any species that is in danger of extinction throughout all or a significant portion of its range. Therefore, based on the information gathered during this review, *E. serpens*, *P. calderonense* and *T. estremerana* continue to meet the definition of endangered.

Recommendation for future action

- Further field surveys are needed to relocate *E. serpens,* if it is still extant.
- Continue evaluating abundance and distribution of *E. serpens*, *P. calderonense* and *T. estremerana* 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 these three fern populations.
- Continue evaluating and implementing conservation measures to minimize possible adverse effects of construction/improvement of communication facilities and forest management practices in Commonwealth forests.
- Continue with the cultivation of the healthy ex situ collections of *P. calderonense* at Fairchild, and incorporate *E. serpens* and *T. estremerana*.
- Establish new self-sustainable populations of *P. calderonense* in protected areas.

Literature cited

Possley, J and J. Lange. 2016. Conservation efforts for federally endangered ferns of Puerto Rico's Cordillera Central: 2014-2016 Summary. Report from Fairchild Tropical Botanic Garden to USFWS Caribbean Field office and Puerto Rico Departmento de Recursos Naturales y Ambientales.

USFWS. 2016. Service Letter to National Science Foundation. Sent on June 24, 2016.