Elaphoglossum serpens,
Polystichum calderonense,
Tectaria estremerana

Status Review:
Summary and Evaluation

Photos by Omar Monsegur (Service)

U.S. Fish and Wildlife Service
South Atlantic-Gulf Region
Caribbean Ecological Services Field Office
Boquerón, Puerto Rico

July 2022

STATUS REVIEW

Elaphoglossum serpens, *Polystichum calderonense*, *Tectaria estremerana*

GENERAL INFORMATION

Current Classification: Endangered

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Reviewers:

Lead Region: Atlanta Regional Office, South Atlantic-Gulf and Mississippi Basin Region, Atlanta, Carrie Straight GA (404) 679-7132.

Date of original listing: June 9, 1993 (58 FR 32308)

Methodology used to complete the review: In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The U.S. Fish and Wildlife Service (Service) evaluated the biology, habitat, and threats of the ferns *Elaphoglossum serpens* (no common name), *Polystichum calderonense* (no common name) and *Tectaria estremerana* (no common name) to inform this status review. Any reference to "three ferns" in this document is a reference to all three of the previously listed species. In most cases all information applies to all three ferns, and where there are differences, they will be explicitly stated. In conducting this 5-year review, we relied on the best available information pertaining to historical and contemporary distributions, life histories, genetics, habitats, and threats of this species. We announced initiation of this review and requested information in a published Federal Register notice with a 60-day comment period on July 14, 2021 (86 FR 37178). We received no public comments during the open comment period. We used a variety of information resources, including monitoring reports, surveys, and other scientific and management information. Specific sources included the final rule listing this species under the Act, peer reviewed scientific publications, unpublished field observations by Federal, State, and other experienced biologists, unpublished studies and survey reports, and notes and communications from other qualified individuals.

Federal Register Notice citation announcing these species us under active review:
July 14, 2021 (86 FR 37178)

Species' Recovery Priority Number at start of review (48 FR 43098): At the time of listing, *Elaphoglossum serpens* and *Polystichum calderonense* were considered species with high degree of threat and a low recovery potential (RPN=5). *Tectaria estremerana* was recognized as a species with moderate degree of threat and high recovery potential (RPN=8).

Review History: Two previous 5-year reviews were published for the three species on January 15, 2010, and July 27, 2017. Both reviews recommended that no change in status was needed for all three species.

REVIEW ANALYSIS

Listed Entity

Taxonomy and nomenclature:
We are not aware of any changes to the taxonomy of these ferns; thus, these species are still considered valid species. However, see the discussion below in Biology and Habitat Summary related to recent genetic studies on *Tectaria estremerana* and past hybridization. Additional studies are being conducted in order to assess if the species can reproduce.

Distinct Population Segment (DPS):
The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing of a DPS to only vertebrate species. Because the species under review are a not a vertebrate, the DPS policy is not applicable.

Recovery Criteria

Recovery Plan:
Recovery Plan Puerto Rican Endangered Ferns *Adiantum vivesii, Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis, Thelypteris verecunda, Thelypteris yaucoensis*, January 17, 1995 (Service 1995)

Amendment to the Recovery Plan for *Adiantum vivesii, Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis, Thelypteris verecunda, Thelypteris yaucoensis*, September 27, 2019 (Service 2019)

The Recovery Plan Amendment establishes that the ferns could be considered for delisting when the following criteria are met:

1. Existing populations (number populations in parentheses) of *E. serpens* (2), *P. calderonenses* (3) and *T. estremerana* (3), *T. verecunda* (3), T. *inabonensis* (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), and *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).

These criteria have not been met for the three ferns that are the focus of this review.

Biology and Habitat Summary

A detailed review of the species' biology and habitat information can be found in the previous 2010 and 2017 5-year status reviews (Service 2010, 2017 respectively).

***Elaphoglossum serpens*:** *Elaphoglossum serpens* is an epiphytic fern presently known from the municipality of Jayuya. During early 2017 FTBG and the Service visited Cerro Punta to search for *E. serpens* without success (Possley and Lange 2017). After being undocumented during surveys at Monte Jayuya and Cerro Punta for the past three decades (i.e., last seen by Proctor in 1991), in 2021, José Sustache (PRDNER) re-discovered two individuals of *E. serpens* at its type locality in Monte Jayuya (see cover photos). An additional individual was found in a mountain on the northwest facing slopes of Monte Jayuya, and another individual in the northern slopes of Cerro Punta, for a total of four individuals (Sustache, PRDNER, pers. comm., 2022). Thus, the overall known individuals of *E. serpens* is four, three in Monte Jayuya and one in Cerro Punta.

Captive Propagation: Later in 2021, FTBG in collaboration with PRDNER and the Service visited areas identified by Sustache to collect fertile fronds of *E. serpens*, aiming to propagate the species and establish an *ex-situ* collection. The spores collected were sent to the Center for Conservation and Research of Endangered Wildlife (CREW) at the Cincinnati Zoo and Botanical Garden for propagation. The latest information is that spores at CREW have been germinating, showing these are viable and that propagation from spores is feasible (Possley, pers. comm., 2022).

Polystichum calderonense: *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 (Service 2010).

During their early 2017 trip to Puerto Rico, FTBG biologists visited the *P. calderonense* population at Silla de Calderón. They documented 14 individuals in healthier conditions than in 2016 and found pockets of good quality habitat in the area (Possley and Lange 2017). Possely and Lange (2017) stated that in 2016, some ferns had brown fronds likely indicating drought stress. They also visited the summit of Monte Guilarte, and although did not see any individuals of *P. calderonense*, they did find and mapped good quality habitat for this species near the summit of Monte Guilarte that could serve for the reintroduction of the species using material they have propagated from Silla de Calderón (Possley and Lange 2017).

Fairchild biologists visited Silla de Calderon in 2022 and recorded seven *P. calderonense* individuals, which is a 50 % reduction since the last visit to this population in 2017 (prior to the impact of Hurricane María). Fairchild biologists also collected three proliferous buds from the species during this site visit for potential future propagation work (Possley, pers. comm., 2022). Currently, these seven plants at Silla de Calderon are the only known wild individuals of the species. Nonetheless, *P. calderonense* has not been searched at Cerrote de Peñuelas where surveys are recommended to verify its presence in that area (Possley and Lange 2017).

Augmentation and Captive Propagation: As of 2020, there were approximately 90 *P. calderonense* individuals (*ex situ*) in pots at FTBG (Possley et al. 2020). Additionally, there are hundreds of small sporophytes in ten germination boxes (Possley et al. 2020). Since these exceed space available at the FTBG nursery, spore boxes were sent to other botanical institutions for cultivation (Possley and Lange 2020). Also, in 2014, spores from 4 genetic lines at Silla de Calderon were sent for long-term storage at the USDA National Laboratory for Genetic Resources Preservation (NLGRP) in Fort Collings, CO (Possley et al. 2020). Later in 2017, additional spores from 2 genetic lines at the FTBG nursery (descended from Silla de Calderón plants) were sent to NLGRP for long-term storage (Possley and Lange 2017).

Planting: In 2021, FTBG biologists visited Puerto Rico and planted 18 of their *P. calderonense* individuals in pots at the University of Puerto Rico's Adjuntas Experimental Station. Also, they planted 3 individuals in a forest remnant at the southern boundary of the Station (Possley 2021), but apparently these three individuals died (Possley, pers. com., 2022).

***Tectaria estremerana*:** *Tectaria estremerana* is a woody terrestrial fern which has been found in the karst region in northern Puerto Rico: Esperanza Ward in the municipality of Arecibo, Río Abajo Commonwealth Forest, and Florida Adentro Ward in the municipality of Florida (Service 2010). During November 2014, FTBG biologists conducted surveys for this species and found 4 individuals at the Río Abajo Commonwealth Forest, and 1 individual at Finca Opiola in Sabana Hoyos Ward, municipality of Arecibo (Possley and Lange 2017, Possley et al. 2020). During 2016, FTBG conducted surveys again and found 3 individuals at the Río Abajo Commonwealth Forest (Possley, pers. comm., 2022). The status of the individuals at Esperanza Ward and Florida Adentro Ward is unknown.

Biologists from FTBG collected samples from several individuals of the species (location not specified) for DNA extraction and sequencing (Possley et al. 2020) in order to determine if *T. estremerana* is actually a hybrid of *T. incisa* and *T. heracleifolia*. In their 2020 report, Possley et al. (2020) shared the results from these genetic samples, suggesting that the species is of hybrid origin. Although in general, this type of molecular analysis helps determine if an individual is of hybrid origin and the parents of hybrids, it does not clarify if the species in question is capable of reproducing (viable spores) (Possley et al. 2020). Nevertheless, based on previous visual assessment of *T. estremerana* spores (lumpy and symmetrical) and unsuccessful germination attempts from spores collected in the wild, Possley et al. (2020) suggests that *T. estremerana* is most likely a sterile hybrid, and

therefore, unable to reproduce. However, Possley et al. (2020) stated that more studies are needed, in order to verify these results, including morphological analysis of the collected plants to make sure those specimens had been rightly identified. Until this analysis is conducted and verified, the Service will continue to treat *Tectaria estremerana* as a valid entity.

Threats (Five-Factor Analysis) Summary

Stressors to these species continue to be the same as described in the previous 2010 and 2017 5-year status reviews (Service 2010 and 2017).

The status of a species is determined from an assessment of factors specified in section 4(a)(1) of the Act, including:

> Factor A (the present or threatened destruction, modification, or curtailment of its habitat or range).
> Factor B (Overutilization for commercial, recreational, scientific, or educational purposes).
> Factor C (disease or predation).
> Factor D (the inadequacy of existing regulatory mechanisms).
> Factor E (other natural or manmade factors affecting its continued existence).

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 primarily threatened by destruction, modification, and curtailment of habitat (Factor A) and other natural or manmade factors affecting its continued existence, e.g., climate change and related events (Factor E).

Communication towers maintenance activities continue to be a threat to *E. serpens* in Cerro Punta (Service 2017, Possley et al. 2020). Additionally, habitat encroachment by weedy exotics occurring at adjacent disturbed habitat at Cerro Punta, Silla de Calderon and the Río Abajo Commonwealth Forest, continues to be a threat to the three species (Possley et al. 2020). For *P. calderonense*, impacts caused by hikers (e.g., vegetation cutting, trampling, soil disturbance, intentional set fires) continues to threaten this species and it was evident at the summit of La Silla de Calderon were hikers cut the vegetation and set a camping site in the proximity of *P. calderonense* individuals (Possley et al. 2020).

Another threat to the habitat and directly to the three ferns are extreme weather events. Hurricanes and tropical storms frequently impact the Caribbean islands, and future projections state that, although there will be a reduction on tropical storms frequency, with a warmer climate there will be an increase of major hurricanes (Runkle et al. 2022) and associated stronger winds. In 2017, the category 5 Hurricane María struck Puerto Rico causing devastating impacts. It is estimated this hurricane killed or severely damaged over 20 million trees throughout Puerto Rico (Feng et al. 2018). Natural disturbance such as hurricanes are a significant threat for many plant species, impacting not only the canopy but also the forest floor and, therefore, the ecosystem dynamics. This is particularly true in

high elevation forests, where these three ferns are found, since higher ground means a greater exposure to stronger winds, where studies have found a positive relationship between elevation and vegetation damage by hurricanes (Hu and Smith 2018). As explained by Lugo (2008), hurricanes strong winds and heavy rains cause tree defoliation and habitat modification due to falling trees, exposing understory plants to an increase light penetration, variable temperatures and changes in moisture conditions (Paciencia and Prado 2005, Kennard et al. 2020,). Increased sunlight is a particular threat to ferns species, because excess direct sunlight can result in the potential death of young individuals and these changes in environmental conditions necessary for successful establishment of new young plants and subsequent recruitment (Service 2022, unpublished data). Ferns have high photosynthetic capacity in habitats with low light and high resistance to phytopathologies (interaction between plant and pathogens), which are common to moist environments (Page 2002), favoring their survival in shaded habitats. For an example, the population of *P. calderonense* at Silla de Calderon is located in the top of the mountain at an area exposed to winds. Thus, an opening in the canopy would increase the species' exposure to winds that could result on the death of the individuals. Therefore, based on the above discussion, canopy openness caused by Hurricane María likely impacted this fern at Silla de Calderon. Moreover, as previously mentioned, the area of Silla de Calderon had been impacted by hikers prior Hurricane María. During the FTBG visit to the area in 2021, a Service biologist reported that the *P. calderonense* habitat was further opened and encroached by weedy vegetation (Service 2022, unpublish data). The canopy openness, coupled with other impacts seen in the area, such as human trampling and exotic grass invasions, were likely the cause of a 50% reduction of this population (Service 2022, unpublished data) as 14 *P. calderonense* individuals were known from this site in early 2017, and in 2021 the population had been reduced to 6 individuals.

Climate change is another factor that could impact all three species' survival. Precipitation is projected to decrease as a result of changes in climate conditions, leading to wet and dry extremes (Jennings et al. 2014). Projections developed by Khalyani et al. (2016), show a faster decrease in precipitation in certain parts of Puerto Rico, such as the central mountain range, where the species (i.e., *P. calderonense* and *E. serpens*) are found. This changes in precipitation will impact species germination capabilities, especially those that depend on moisture for germination, such as ferns. Additionally, a projected shift in life zones, from humid to drier (Khalyani et al. 2016) is a particular risk for species with limited distribution and that occur in specific habitats (e.g., mountains peaks), such as *E. serpens* and *P. calderonense*.

The above-mentioned threats are exacerbated by the limited distribution, fragmented habitats, low number of individuals, and small population size of all three species, which make them vulnerable to natural and stochastic events, such as hurricanes and climate change (i.e., changes in precipitation). Additionally, these characteristics likely reduce their ability to adapt to changing environmental conditions.

Synthesis

Elaphoglossum serpens, Polystichum calderonense, and *Tectaria estremerana* are three narrowly endemic fern species of Puerto Rico, with less than five localities known for each

one. Two of these species, *P. calderonense* and *E. serpens*, are restricted to high-elevation elfin forest near the summit of mountains. *Tectaria estremerana* is known from pockets of habitat amongst limestone boulders in the northern karst hills of Puerto Rico. The three species are not only limited in distribution, but also composed of a small number of individuals. The most recent information for *P. calderonense* indicates there are only seven individuals of the species at one of its three known localities (i.e., Silla de Calderón). It was not found at a second location, Monte Guilarte, and the third location, Cerrote Peñuelas, has not been surveyed. Available information on *E. serpens* indicates four recently discovered individuals of this species, three in Monte Jayuya and one in Cerro Punta. The most recent survey for *T. estremerana* showed that there are 3 individuals at the Río Abajo Commonwealth Forest and one individual at Finca Opiola, municipality of Arecibo. The status of this species at two other locations (i.e., Esperanza Ward and Florida Adentro Ward, municipality of Arecibo) is unknown. Moreover, preliminary genetic studies indicate the validity of *T. estremerana* as a true species is in question. However, additional studies are needed to corroborate its validity as a species. Until these analyses are conducted and verified, the Service will continue to treat *Tectaria estremerana* as a valid entity.

Some recent changes in populations include the recent discovery of four individuals of *E. serpens* in the central mountain range of Puerto Rico, and a 50% decline in the population of *P. calderonense* at Silla de Calderon, which was likely associated with hurricane damage, exotic grass invasion, and human trampling. All three fern species continue to be threatened by the destruction, modification, and curtailment of habitat, damage from hurricanes, trampling, invasive species, and climate change. These threats are exacerbated by the species' low number of individuals, low population numbers, and limited distribution. Because of these reasons, each of these species continues to meet the definition of endangered species.

RESULTS / APPROVALS

U.S. FISH AND WILDLIFE SERVICE
STATUS REVIEW of *Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*

Status Recommendation:

On the basis of this review, we recommend the following status for this species. A 5-year review presents a recommendation of the species status. Any change to the status requires a separate rulemaking process that includes public review and comment, as defined in the Act.

____ Downlist to Threatened
____ Delist *(Indicate reasons for delisting per 50 CFR 424.11)*:
____ *The species is extinct*
____ *The species does not meet the definition of an endangered or threatened species.*
____ *The listed entity does not meet the statutory definition of a species.*
_X_ No change needed, all three species remain listed as endangered

FIELD OFFICE APPROVAL:

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

Approve EDWIN MUNIZ Digitally signed by EDWIN MUNIZ Date: 2022.08.01 16:10:32 -04'00'

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

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 estremerana* 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.

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