

RECOVERY PLAN

Puerto Rican Endangered Ferns

Adiantum vivesii

Elaphoglossum serpens

Polystichum calderonense

Tectaria estremerana

Thelypteris inabonensis

Thelypteris verecunda

Thelypteris yaucoensis



U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

PUERTO RICAN ENDANGERED FERNS RECOVERY PLAN

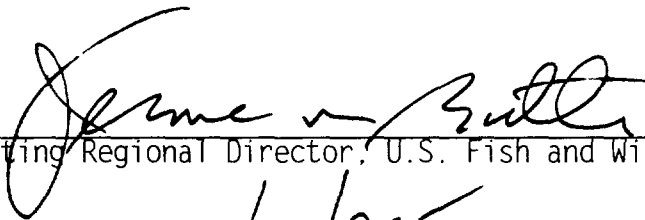
prepared by

Marelisa Rivera
U.S. Fish and Wildlife Service
Caribbean Field Office
Boquerón, Puerto Rico

for the

U.S. Department of the Interior
Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

Approved:


Acting Regional Director, U.S. Fish and Wildlife Service

Date:

1/17/95

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State (Commonwealth) agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature Citations should read as follows:

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

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814

Telephone: 301/492-6403 or
1-800-582-3421

Fees for recovery plans vary, depending upon the number of pages.

EXECUTIVE SUMMARY

Current Status: *Adiantum vivesii*, *Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* are listed as endangered. These seven ferns are endemic to the island of Puerto Rico and are currently restricted to three or fewer localities each.

Habitat Requirements and Limiting Factors: *Adiantum vivesii* and *Tectaria estremerana* have each been reported from only one location in the limestone hills of northern Puerto Rico (Quebradillas and Arecibo, respectively). *Elaphoglossum serpens* is found at a single site in the montane dwarf forest of the summit of Cerro Punta in the central mountains, municipality of Jayuya. *Polystichum calderonense* is known from only two localities, Monte Guilarte Commonwealth Forest in Adjuntas and Cerrote Peñuelas in the municipality of Peñuelas. *Thelypteris inabonensis* is only known from high elevation wet montane forest in two localities, the headwaters of the Río Inabón in Ponce and Cerro Rosa in the municipality of Ciales. Both areas are located within the Toro Negro Commonwealth Forest. *Thelypteris verecunda* is found at Charcas Ward in Quebradillas, Bayaney Ward in Hatillo, and Cidral Ward in the municipality of San Sebastián. *Thelypteris yaucoensis* is known from two localities in Yauco and one locality in Ciales, and grows in humus on steep, shaded rocky banks, and ledges at high elevations.

Recovery Objective: Downlisting.

Recovery Criteria: Existing populations and their habitats should be protected, and self-sustaining populations must be established in protected areas.

Actions Needed:

1. Prevent further habitat loss and population decline.
2. Continue to gather information on the distribution and abundance of the seven endangered ferns.
3. Conduct research on habitat requirements, reproductive biology, and ecology of the seven species.
4. Establish new populations.
5. Refine recovery goals.

Date of Recovery: Downlisting should be initiated in 2010, if recovery criteria are met.

Recovery Costs: Recovery costs for the seven species have been estimated at \$113,000 for the first 3 years. Subsequent expenditures will depend on the results of these preliminary studies and activities, and therefore cannot be estimated at this time.

TABLE OF CONTENTS

	Page
PART I. INTRODUCTION	
Description	1
Ferns of the Karst Region	1
Ferns of the Central Mountains	3
Distribution and Population Status	4
Ferns of the Karst Region	4
Ferns of the Central Mountains	6
Habitat Description	6
Karst Region	6
Central Mountains	7
Reasons For Listing	8
Conservation Measures	9
Summary of Comments Received	9
PART II. RECOVERY	
A. Recovery Objective	11
B. Narrative Outline	11
C. Literature Cited	16
PART III. IMPLEMENTATION SCHEDULE	17
PART IV. LIST OF REVIEWERS	22

PART I. INTRODUCTION

Adiantum vivesii, *Elaphoglossum serpens*, *Polystichum calderonense*, *Tectaria estremerana*, *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis*, all ferns endemic to the island of Puerto Rico, are currently restricted to no more than three locations each. These species are all terrestrial ferns, with the exception of *Elaphoglossum serpens*, which is epiphytic. *Adiantum vivesii* and *Tectaria estremerana* have each been reported from only one locality in the limestone hills of northern Puerto Rico. *Elaphoglossum serpens* is found growing on only six moss covered trees in the montane dwarf forest of the summit of Cerro Punta in the central mountains. *Polystichum calderonense* is known from only two localities, Monte Guilarte Commonwealth Forest and Cerrote Peñuelas. *Thelypteris inabonensis* is known from two localities, both in wet montane forest at high elevations, in the Toro Negro Commonwealth Forest. *Thelypteris verecunda* and *Thelypteris yaucoensis* are known from three localities each. *Thelypteris verecunda* is found in Quebradillas, Hatillo, and San Sebastián, in privately owned lands. *Thelypteris yaucoensis* grows in humus on steep, shaded rocky banks and ledges at high elevations at Los Tres Picachos in Ciales and two localities in the municipality of Yauco. All seven species of ferns are threatened by habitat destruction and modification, forest management practices, hurricane damage, and possible collection.

Adiantum vivesii, *Elaphoglossum serpens*, *Polystichum calderonense*, and *Tectaria estremerana* were determined to be endangered species on June 9, 1993 (U.S. Fish and Wildlife Service 1993a) and *Thelypteris inabonensis*, *Thelypteris verecunda*, and *Thelypteris yaucoensis* were determined to be endangered species on July 2, 1993 (U.S. Fish and Wildlife Service 1993b), pursuant to the Endangered Species Act of 1973, as amended.

Critical habitat has not been designated for these species because of the risk of vandalism and the possibility of overcollection.

Description

Ferns of the Karst Region:

Adiantum vivesii (Adiantaceae) was described by Dr. George R. Proctor in 1985 from specimens collected by Miguel Vives and William Estremera at San Antonio Ward in the municipality of Quebradillas (Proctor 1989). At present, *A. vivesii* is only known from this locality.

Adiantum vivesii is a gregarious colonial fern with creeping, nodose 2.5- to 3-millimeter (mm)-thick rhizomes. The fronds are distichous and erect-spreading, approximately 0.5 centimeters (cm) apart and 45 to 71 cm long. The stipes or stalks are lustrous purple-black, 25 to 46 cm long, irregularly branched, and have hairlike scales. The frond's blades are broad and irregular, 20 to 28 cm long, and 23 to 35 cm broad. The rachis and costae are more densely covered with hairlike scales than the stipe. The blades have 2 or 3 alternate or occasionally subopposite pinnae, with a larger terminal pinnae. These are lance-oblong, 13 to 20 cm long, and 3.5 to 5 cm broad. The terminal pinna may

be up to 7 cm broad, and is stalked and often somewhat inequilateral. Each pinna has 10 to 13 pairs of alternate, narrowly oblong-falcate pinnules, which are unequally cuneate at base. The outer sterile margins of the pinna are irregularly serrulate, and the tissue is dull green on both sides. Five elliptic to linear sori are borne along the basal half of the acroscopic margin. The sori are close or contiguous, but remain distinct. The indusoid is gray-brown, turgid, with an erose margin (Proctor 1989).

Tectaria estremerana (Dryopteridaceae) was described by Proctor and Evans in 1984 from specimens collected by William Estremera at Esperanza Ward, Arecibo, in the vicinity of the Arecibo Radio Telescope (Proctor 1989). This species was known only from this site. More recent observations indicate that the species does occur in the Río Abajo Forest and in the municipality of Florida (Axelrod personal communication).

Tectaria estremerana has a woody, erect, 10- to 15-mm-thick rhizome. The rhizome's apex bears a dense tuft of erect, brown, glabrous, narrowly deltate-at-tenuate scales about 15 mm long and 0.5 to 0.8 mm wide at the base. This fern has several loosely fasciculate, 65- to 80- cm-long fronds. The light orange-brown stipes are slightly shorter than the blades and are covered with pale jointed hairs. Scales up to 12 mm long clothe the base. The blades are oblong-ovate, 35 to 41 cm long, 20 to 25 cm broad below the middle, and acuminate at the pinnatifid apex. The rachis, the costae, and the costules are softly puberulous with articulate hairs on both sides. This fern has 3 to 4 pairs of free pinnae, and has several distal divisions which are more or less adnate. The basal pair of pinnae is deltate-oblong, strongly inequilateral, 12 to 13 cm long, and coarsely lobate or subpinnatifid. The lobes are from 9 to 13 mm broad except for the larger basal basiocopic ones. The tissue is firmly herbaceous, glabrous, but the margins are ciliate. The sori are located nearer to the midvein than the margin of the pinna-lobes (Proctor 1989).

Thelypteris verecunda (Thelypteridaceae) was described by Dr. George R. Proctor in 1985 from specimens collected from Charcas Ward in the municipality of Quebradillas (Proctor 1989). Two other localities are known for the species: Bayaney Ward, Hatillo, and Cidral Ward in the municipality of San Sebastián.

Thelypteris verecunda is 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

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 sori, which have a minute indusium, are located in an inframedial position, and bear a tuft of long, white, simple hair (Proctor 1989).

Ferns of the Central Mountains:

Elaphoglossum serpens (Lomariopsidaceae) was described by Maxon in 1947 from specimens on tree trunks at Monte Jayuya (Liogier and Martorell 1982), but the fern is now extirpated from this site due to construction of a communication facility. It was later found by Roy O. Woodbury et al., on the summit of Cerro Punta (Proctor 1991).

Elaphoglossum serpens is an epiphytic fern with a wide-creeping, 1.5- to 2-mm-thick rhizome. The apex and nodes bear lanceolate to attenuate, 3- to 4-mm-long, lustrous, reddish-brown scales which have ciliate margins. This species has only a few, distant, and erect fronds. Sterile fronds are 7 to 19 cm long and the stipes, from 3.5 to 11 cm in length, are usually as long or longer than the blades. The blades are ovate, 3.5 to 8 cm long and 2 to 3.5 cm broad, obtuse at the apex, and cuneate at the base. The veins are free, reaching the margins of the blades. The coriaceous tissue is opaque with only scattered scales on the abaxial side. The fertile fronds are 8.5 to 18 cm long, and in contrast to the sterile fronds, the stipes are about three times longer than the blades. The blades are 2.5 to 4 cm long and 1 to 1.5 cm broad, and are lanceolate to elliptic-oblong with rounded or blunt apex (Proctor 1989).

Polystichum calderonense (Dryopteridaceae) was described by Dr. George Proctor in 1985 from specimens collected from the summit of La Silla de Calderón, Monte Guilarte Commonwealth Forest, in the municipality of Adjuntas (Proctor 1989). A second population was found in 1987 on Cerrote de Peñuelas, in the municipality of Peñuelas, by Dr. Proctor with Dr. Haneke (Proctor 1991). At present, this species is known to occur only at these two localities.

Polystichum calderonense is 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).

Thelypteris inabonensis (Thelypteridaceae) was described by Dr. George R. Proctor in 1985 from specimens collected at the headwaters of the Río Inabón in the municipality of Ponce (Proctor 1989). In 1988, it was found near the summit of Cerro Rosa in the municipality of Ciales. No other localities for this species are known (Proctor 1991).

Thelypteris inabonensis is 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 sori, which has a densely long-ciliate indusium, are located dorsal on veins (Proctor 1989).

Thelypteris yaucoensis (Thelypteridaceae) was described by Dr. George R. Proctor in 1984 from specimens collected at Rubias Ward in the municipality of Yauco (Proctor 1989). This species is also known from two other localities: Los Tres Picachos, Toro Negro Ward in Ciales and the summit area of Pico Rodadero, Sierra Alta Ward, in the municipality of Yauco.

Thelypteris yaucoensis is 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).

Distribution and Population Status (Figure 1)

Ferns of the Karst Region:

Adiantum vivesii is known only to occur in a single locality. An estimated 1,000 plants, or growing apices, have been reported at the base of a north-facing limestone cliff in the municipality of Quebradillas in northern Puerto Rico (Proctor 1991). The site is privately owned.

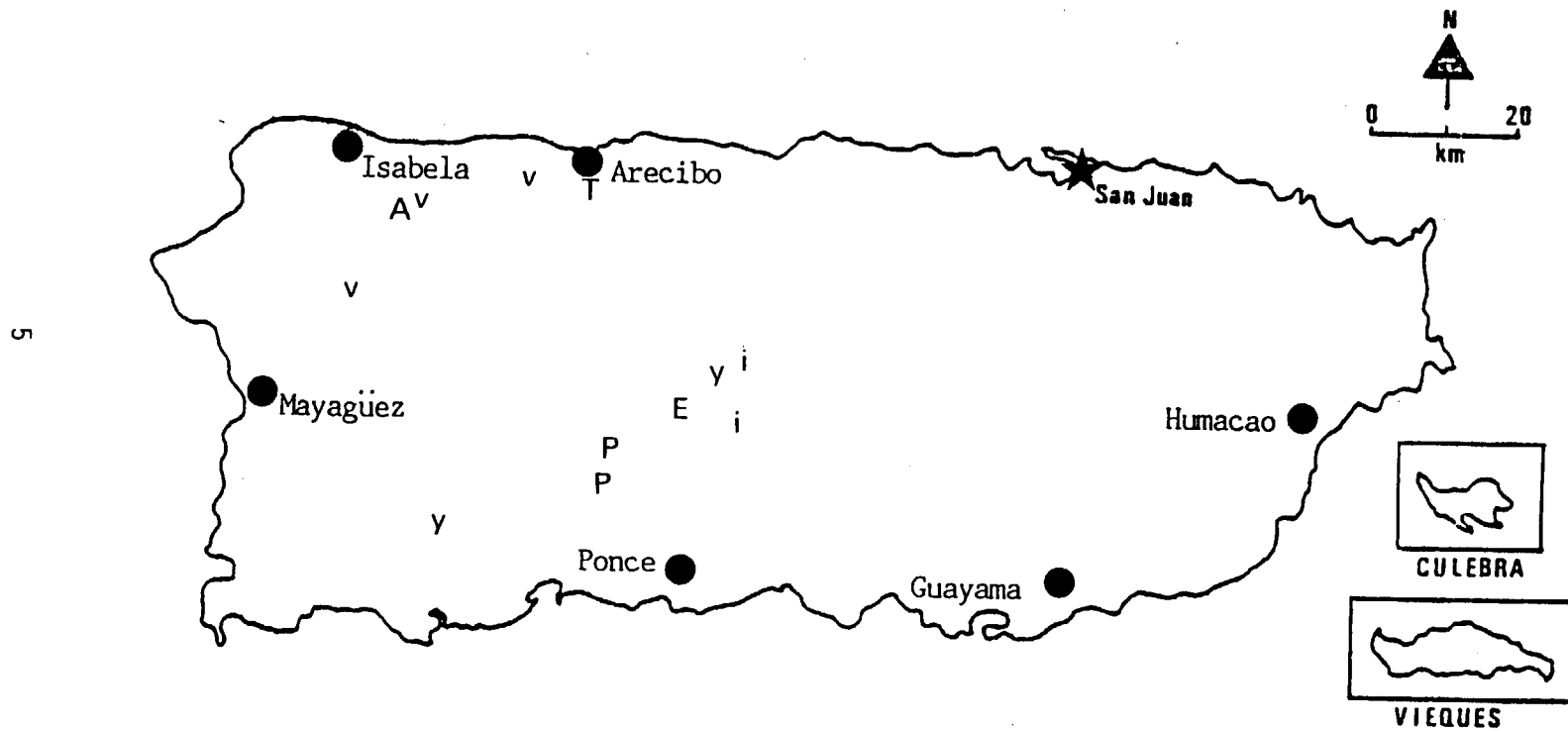


Figure 1. Distribution of Puerto Rican Endangered Ferns: *Adiantum vivesii* (A), *Elaphoglossum serpens* (E), *Polystichum calderonense* (P), *Tectaria estremerana* (T), *Thelypteris inabonensis* (i), *Thelypteris verecunda* (v), and *Thelypteris yaucoensis* (y).

Tectaria estremerana was known from only one site located in the municipality of Arecibo, within the property of the Arecibo Radio Telescope managed by Cornell University under a cooperative agreement from National Science Foundation. Approximately 23 individual plants were found in the area (Proctor 1989). Dr. Franklin Axelrod, in a letter dated September 9, 1994, mentioned that this species was collected by him in the Río Abajo Commonwealth Forest in Arecibo and in a sinkhole near an old quarry in Florida, Abajo Ward in the municipality of Florida.

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

Ferns of the Central Mountains:

Elaphoglossum serpens is presently known from Cerro Punta in the municipality of Jayuya. Only 22 plants are known from the summit area, all of which occur on the mossy trunks of only six trees (Proctor 1991). These trees are found at an elevation of about 1,300 meters in a patch of a montane dwarf forest within the Toro Negro Commonwealth Forest. This patch of forest is all that has survived the construction of telecommunication towers in the summit area, and was badly damaged in 1989 by Hurricane Hugo (Proctor 1991).

Polystichum calderonense is found at two localities. Forty-five individual plants (including juveniles) are known from La Silla de Calderón, and twelve from Cerrote Peñuelas (Proctor 1991). La Silla de Calderón is located within Monte Guilarte Commonwealth Forest in the municipality of Adjuntas, but Cerrote Peñuelas is privately owned.

Thelypteris inabonensis is known from two localities in the Toro Negro Commonwealth Forest: the headwaters of the Río Inabón in Ponce and Cerro Rosa in Ciales. Forty-six plants were counted in both localities combined (Proctor 1991).

Thelypteris yaucoensis is known from Rubias Ward and Pico Rodadero in Yauco, and Los Tres Picachos in Ciales. Approximately 65 individuals have been estimated at these three sites (Proctor 1991).

Habitat Description

Karst Region:

Adiantum vivesii, *Tectaria estremerana* and *Thelypteris verecunda* are found in the limestone or karst region of northwestern Puerto Rico. This region is underlain by limestone rocks of Oligocene or Miocene age. Topography varies throughout the karst region, from extremely rugged to gentle rolling hills. Canyons, sinkholes, and subterranean rivers, as well as these rolling hills, are the most common features of the region.

Soils in the limestone hills are shallow, well-drained, alkaline, and interspersed between limestone outcrops (Soil Conservation Service 1975).

Populations occur within the semi-evergreen seasonal forests of the subtropical moist forest life zone (Ewel and Whitmore 1973). This life zone, which covers 58 percent of the total area in Puerto Rico and the U.S. Virgin Islands, is delineated by a mean annual rainfall of 1,000 or 1,100 millimeters to about 2,000 or 2,200 millimeters and a mean temperature between about 18 and 24 degrees Centigrade (Ewel and Whitmore 1973). The limestone hills, which are oriented northeast to southwest, are moist on the gentle northern slopes, are even more humid on the extremely steep southwestern slopes, but are quite xeric on top (Monroe 1976).

Adiantum vivesii occurs in a deeply shaded hollow at the base of a limestone hill in Quebradillas. *Tectaria estremarana* grows in moist, shaded humus on and among limestone boulders on a wooded rocky hillside at 250 to 300 meters elevation in the municipality of Arecibo. *Thelypteris verecunda* grows in moist, shaded, limestone ledges at middle elevation (200 meters) in Quebradillas, Hatillo, and San Sebastián.

Central Mountains:

The other four species are found in the mountains of the central region of Puerto Rico. The central mountains are upper Cretaceous, volcanic in origin. Igneous rocks, mostly andesitic types, cover the area. The clay soils are deep, well-drained, very strongly acid, and overlay a thick layer on highly weathered rock. A deep humus layer is present on the forest floor. Tree roots often form a tight superficial mat (Gierbolini 1979).

Elaphoglossum serpens is an epiphytic fern that occurs on the summit of Cerro Punta, the highest peak in the central mountains of Puerto Rico, within the Toro Negro Commonwealth Forest. The species is found growing on the mossy trunks of six trees on montane dwarf or elfin forest at approximately 1,300 meters elevation. Several of these trees have been identified as *Lyonia rubiginosa* var. *stahlia*, which has few known localities (Proctor 1991). Topography is rough and highly dissected by intermittent streams, but the elfin forest is found on the more rounded mountain tops.

Average annual precipitation (1969-1979) at Cerro Maravilla, east of Cerro Punta (elevation 3,900 feet or 1,200 meters) is 2,338 millimeters (92 inches). The major peak in rainfall occurs in September and October, with a secondary peak in May. Average annual temperature at the same station is 18.4 degrees Centigrade with an average monthly maximum of 19.8 degrees Centigrade in July and August and a minimum of 16.7 degrees Centigrade in January. The estimated potential evapotranspiration is 1,140 millimeters, less than half of the annual precipitation received in this area (Department of Natural Resources 1986).

The vegetation of the high elevations of the central mountains has been called dwarf, elfin, or cloud forest (Howard 1968, Ewel and Whitmore 1973). Ewel and Whitmore (1973) have described Toro Negro as the subtropical lower montane wet forest life zone. The vegetation is characterized by a single canopy layer that seldom exceeds 7 meters (22 feet) in height. Gnarled and much branching trees form a dense thicket and mosses, liverworts, and bromeliads are abundant. Leaves are microphyllous, sclerophyllous, and clustered at the tips of branches. Among the causes cited as responsible for the dwarfed nature of the vegetation at these high elevations are strong wind, waterlogged and nutrient-poor soils, shallow and poorly developed root systems, and inefficient base pumping due to low transpiration rates (Howard 1968, Weaver et al., 1973).

Thelypteris inabonensis also grows in the lower montane wet forest life zone at elevations of 1,120 to 1,250 meters. At the type locality, this species grows along a stream bank in sierra palm (*Prestoea montana*) forest, on the eastern bank of the Río Inabón in the municipality of Ponce. Proctor (1991) reported other rare plants from this locality, such as *Elaphoglossum smithii*, *Grammitis anfractuosa*, and *Ranunculus recurvatus* var. *tropicus*. At the Cerro Rosa locality in the municipality of Ciales, the species was found in deeply-shaded humus near the summit area. The habitat of the second locality is mossy forest with sierra palms. Both localities are also within the boundaries of the Toro Negro Commonwealth Forest.

Polystichum calderonense is found growing on moist, shaded, non-calcareous ledges on mountain tops at elevations of 1,000 to 1,150 meters in central and south-central Puerto Rico. Ewel and Whitmore (1973) have described these areas as subtropical wet forest (Monte Guilarte) and subtropical moist forest (Peñuelas) life zones. Average annual precipitation at a nearby station in Adjuntas is 2,001 millimeters (78.7 inches). The major peak in rainfall occurs in September and October with a secondary peak in May. Average annual temperature at this same station is 21.3 degrees Centigrade with an average monthly maximum of 22.9 degrees Centigrade in August and a minimum of 19.2 degrees Centigrade in January (Department of Natural Resources 1986).

Thelypteris yaucoensis grows in humus on steep, shaded, rocky banks and ledges at high elevations (850 to 1,200 meters) in the municipalities of Yauco and Ciales. These sites are located within the subtropical moist forest life zone (Ewel and Whitmore 1973).

Reasons For Listing

Destruction and modification of habitat may be the most significant factors affecting the numbers and distribution of these seven endemic ferns. These species are rare, extremely restricted in distribution, and vulnerable to habitat destruction or modification. The extreme rarity of these species makes the loss of any one individual even more critical. Also, these species could be attractive items for collectors.

Three of the species (*Adiantum vivesii*, *Elaphoglossum serpens*, and *Tectaria estremerana*) are each known from only one site. Clearing or development of these areas would result in elimination of the only known populations. The other four species are each known from only two or three sites.

Adiantum vivesii, *Thelypteris verecunda* and *Thelypteris yaucoensis* occur only on privately-owned lands. *Polystichum calderonense* occurs on both privately- and publicly-owned lands. Although *Elaphoglossum serpens* occurs in a Commonwealth forest, the construction of communications facilities at Monte Jayuya destroyed the only other known population of this species, and such facilities encroach upon the population at Cerro Punta. The patch of forest where *Elaphoglossum serpens* is found was badly damaged in 1989 by Hurricane Hugo.

Although *Elaphoglossum serpens*, *Polystichum calderonense*, and *Thelypteris inabonensis* occur within Commonwealth forests, these populations may be affected by forest management practices. *Tectaria estremerana* is located about only 200 meters south of the Arecibo Radio Telescope; any expansion or development of the facilities may have adverse effects on the habitat of this fern species. The localities for *Polystichum calderonense* were identified by Proctor (1991) as vulnerable to indiscriminate cutting or fires. In Peñuelas, this species occurs on private land which may be affected by industrial or residential development.

Conservation Measures

Following the listing of these species as endangered by the U.S. Fish and Wildlife Service (Service), the Puerto Rico Department of Natural and Environmental Resources (DNER) also began protecting these species through its Regulation to Govern the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico. The Department, as well as the Service, considers these fern species when reviewing development projects within the known range of the species or within their potential habitat.

Summary of Comments Received

A copy of the Technical/Agency Draft Recovery Plan for Puerto Rican Endangered Ferns was sent to 15 reviewers, including three peer reviewers, for review and comments. A notice of availability of the Technical/Agency Draft was published in the Federal Register on July 7, 1994. Four comment letters were received.

The U.S. Forest Service, International Institute of Tropical Forestry, supported the plan and endorsed its content and recommendations. The Director of the Arecibo Observatory supported the plan and invited the Service to discuss appropriate steps to protect *Tectaria estremerana* at the Observatory.

The U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Washington, D.C., mentioned that management practices at the Arecibo Observatory and the Toro Negro Commonwealth Forest possibly included the use of herbicides to keep the area free of weed. Information on criteria to evaluate possible effects of pesticides on these species was provided. The population of *Tectaria estremarana* had been visited several times by Service biologists, and the use of herbicides in the area or adjacent areas had not been observed. The area where the population is found had not been disturbed by the operation of the observatory. *Elaphoglossum serpens* is the fern species found in the Toro Negro Commonwealth Forest. The use of herbicides for weeds control had not been identified as a threat for the species since it is an epiphytic species.

Comments supplying supplemental data have been incorporated into the appropriate sections of this plan.

PART II. RECOVERY

A. Recovery Objective

The objective of this recovery plan is to provide direction for reversing the decline of the seven fern species and for restoring the species to a self-sustaining status, thereby permitting them to be eventually removed from the Federal Endangered Species List.

The seven fern species could be considered for downlisting when (1) the known populations are placed under protective status; (2) an agreement between the Service and the DNER concerning the protection of the three species in Commonwealth forests has been developed and implemented; (3) an agreement between the Service and Cornell University concerning the protection of *Tectaria estremarana* on the Arecibo Radio Telescope property has been prepared and implemented; and, (4) new populations (the number of which should be determined following the appropriate studies) capable of self perpetuation have been established within protected areas.

B. Narrative Outline

1. 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.
 11. Protect existing populations.
The protection of existing populations and their habitat must be given the highest priority.
 111. Obtain protective status for the populations at privately owned sites.
~~Privately-owned sites should be protected through land acquisition, the establishment of conservation easements, or through landowner agreements.~~
 112. Develop management plans, in cooperation with the Department of Natural and Environmental Resources, for Toro Negro and Monte Guiltarte Commonwealth Forests for the protection of *Elaphoglossum serpens*, *Thelypteris inabonensis*, and *Polystichum calderonense*.
~~Management plans should be developed that include measures to protect known populations and their habitat and provide for long-term monitoring of their growth and reproduction.~~

113. Develop a management plan, in cooperation with Cornell University for the Arecibo Radio Telescope, for the protection of *Lectaria estremera*.
Management plans should be developed and implemented to protect the only known population of this species and to provide long-term monitoring of its growth and reproduction.
12. Monitor populations.
Individual plants and the recruitment of new individuals at all sites must be monitored on a long-term basis. Basic field observations on population biology, including phenology, spore production and dispersal, recruitment success, site changes, and growth, should be conducted.
13. Enforce existing Commonwealth and Federal endangered species regulations.
The Commonwealth Department of Natural and Environmental Resources' Regulation to Govern the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico of 1985 provides for criminal penalties for the illegal take of listed plant species on public lands. In addition, development projects which occur in these areas are often funded through local or Federal agencies or require local permits. Section 10 of the Regulation provides for consultations on endangered species that may be affected by a particular project, similar to Section 7 of the Federal Endangered Species Act.
14. Educate the public on plant conservation values and regulations pertaining to endangered species.
Both Federal and Commonwealth agencies should become involved in the education of the public on general conservation values, as well as on the importance of protecting endangered plants and the laws related to their protection. Slide presentations and illustrated material (in Spanish) on endangered plants and plant communities for presentation to local school groups and organizations should be emphasized. These might be combined with a general presentation on all endangered species. Project consultants and permitting and funding agencies should be made aware of endangered plants, the laws involved, and their responsibilities.

2. 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.
 21. Search for new populations.
Searches for new populations in the karst region and the central mountains in Puerto Rico should be conducted.
 211. Identify and inventory potential sites.
Based on a characterization of known habitat types, potential population sites should be identified and searched. Coordinating agencies and organizations in this effort might be the U.S. Fish and Wildlife Service, the Forest Service Area of the Puerto Rico Department of Natural and Environmental Resources, the Puerto Rico Natural Heritage Program, the University of Puerto Rico, and private conservation organizations.
 212. Characterize sites to determine their suitability as future recovery sites.
If new populations are discovered, this information should be added to the databases of the various agencies and organizations involved. In addition, sites should be evaluated for the availability of propagative material and the potential for protection. On sites identified as potential habitat, but where no plants are found, the suitability of the site for introduction of individuals should be determined.
3. Conduct research.
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.
 31. Define habitat requirements.
Studies to define habitat requirements should be conducted.

32. Study reproductive biology and ecology of the seven fern species.
Very little information is currently available concerning the reproductive biology of these species in their natural habitat. Effective management and recovery depends upon obtaining this information.
312. Assess periodicity of spore production and dispersion.
The frequency, timing, and the physical and biological factors controlling spore production and dispersion should be determined.
313. Assess spore viability and germination requirements. Evaluate the proportion of viable spores produced and the environmental conditions required for germination.
314. Evaluate gametophyte establishment and growth, the requirements for fertilization and sporophyte establishment and growth.
Field and laboratory experiments should focus on these critical stages in order to determine the factors which affect establishment and survival.
33. Evaluate feasibility of artificial propagation and develop propagation program.
Propagation techniques should be evaluated and, utilizing this information, a propagation program with local nurseries may be developed.
331. Assess feasibility of propagation.
Based on the availability of propagative material, economic and logistical considerations, and results from the above research, determine the most feasible methods of propagation and transplantation to existing or new sites.
332. Develop artificial propagation program.
These fern species should be included in the ongoing artificial propagation program at local nurseries.
4. Establish new populations.
Areas for the establishment of new populations of the seven fern species should be selected and new populations established.

41. Select appropriate sites for population introduction or enhancement using artificially propagated material.
Habitat requirements must be considered in order to assure the success and relevance of transplanting propagated material.
 411. Select sites and assess habitat suitability.
Using information from Tasks 211 and 31, inventory potential sites for the introduction and establishment of new populations of the seven fern species.
 412. Assure site protection.
If proposed sites are not already on protected land, steps must be taken to provide such protection for new populations. Management plans for these new sites should be developed or modified to include considerations for these species.
 413. Introduce and monitor plants.
Success of plantings should be carefully monitored.
5. 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.
 51. Determine numbers of individuals and populations necessary to ensure species stability, security, and self-perpetuation. Environmental and reproductive studies, together with the relative success of population protection measures, will allow more precise and realistic recovery goals to be established.
 52. Determine what additional actions, if any, are necessary to achieve recovery objectives.
If there are any actions not included in this recovery plan which, during the recovery process, become recognized as species' needs, they should be incorporated into the plan.

C. Literature Cited

- Department of Natural Resources. 1986. Los Bosques de Puerto Rico. In Compendio Enciclopédico de los Recursos Naturales de Puerto Rico. Estado Libre Asociado de Puerto Rico, San Juan.
- Ewel, J.S. and J.L. Whitmore. 1973. Ecological life zones of Puerto Rico and the U.S. Virgin Islands. U.S.D.A. - Forest Serv. Res. Paper ITF-18. 72 pp.
- Gierbolini, R.E. 1979. Soil Survey of the Ponce Area of Southern Puerto Rico. U.S.D.A. Soil Conservation Service in cooperation with the University of Puerto Rico.
- Howard, R.A. 1968. The ecology of an elfin forest in Puerto Rico: Introduction and composition studies. J. Arnold Arboretum 49 (4):381-418.
- Liogier, H. A. and L. F. Martorell. 1982. Flora of Puerto Rico and adjacent islands: a systematic synopsis. University of Puerto Rico, Río Piedras, Puerto Rico. 342 pp.
- Monroe, W.H. 1976. The karst landforms of Puerto Rico. Geological Survey Prof. Paper 899.
- Proctor, G.R. 1989. Ferns of Puerto Rico and the Virgin Islands. The New York Botanical Garden, Bronx, New York. 389 pp.
- Proctor, G.R. 1991. Puerto Rican Plant Species of Special Concern; Status and Recommendations. Publicación Científica Miscelánea No. 2, Departamento de Recursos Naturales, San Juan, Puerto Rico. 196 pp.
- Soil Conservation Service. 1975. Soil Surveys of Mayaguez Area of Western Puerto Rico. U.S. Department of Agriculture, Soil Conservation Service, in cooperation with University of Puerto Rico, College of Agricultural Sciences. 296 pp.
- U.S. Fish and Wildlife Service. 1993a. Endangered and threatened wildlife and plants; determination of endangered status for four endemic Puerto Rican ferns. Federal Register Vol. 58 (109):32308-32311.
- U.S. Fish and Wildlife Service. 1993b. Endangered and threatened wildlife and plants; determination of endangered status for three endemic Puerto Rican ferns. Federal Register Vol. 58 (126):35888-35891.
- Weaver, P.L., M.D. Byer, and D. Bruck. 1973. Transpiration rates in the Luquillo Mountains of Puerto Rico. Biotropica 5 (2):123-133.

PART III. IMPLEMENTATION SCHEDULE

Priorities in Column 4 of the following Implementation Schedule are assigned as follows:

- Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
- Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
- Priority 3: All other actions necessary to provide for full recovery of the species.

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				REG	FWS DIV	OTHER	FY1	FY2	FY3	
1	111	Obtain protective status for the privately owned population sites.	4	4	TE	PRDNER				Cost cannot be determined at present due to the possibility of conservation easements or land-owner agreements.
1	112	Develop management plans, in cooperation with the Department of Natural and Environmental Resources for Toro Negro and Monte Guilarte Commonwealth Forests for the protection of <i>Elaphoglossum serpens</i> , <i>Thelypteris inabonensis</i> and <i>Polystichum calderonense</i> .	4	4	TE	PRDNER				No cost anticipated.
1	113	Develop a management plan, in cooperation with Cornell University for the Arecibo Radio Telescope for the protection of <i>Tectaria estremerana</i> .	4	4	TE	Cornell Univ.				No cost anticipated.

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				REG	FWS DIV	OTHER	FY1	FY2	FY3	
1	121	Monitor known populations.	Cont.	4	TE	PRDNER & Universities	5	5	5	
1	122	Enforce existing Commonwealth and Federal endangered species regulations.	Cont.	4	TE LE	PRDNER	9	9	9	One PRDNER ranger half-time
2	123	Educate the public on plant conservation values and regulations pertaining to endangered species.	Cont.	4	TE	PRDNER & Universities	No cost anticipated.			
2	211	Identify and inventory potential sites.	2	4	TE	PRDNER, Universities, and Conservation Organizations	10			
2	212	Characterize sites to determine their suitability as future recovery sites.	2	4	TE	PRDNER, Universities, and Conservation Organizations	No cost anticipated.			
2	31	Define habitat requirements.	2-4	4	TE	PRDNER, Universities, and Conservation Organizations	5	5	5	

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				REG	FWS DIV	OTHER	FY1	FY2	FY3	
2	312	Assess periodicity of spore production and dispersion.	2	4	TE	PRDNER, Universities, and Conservation Organizations	10	10		10K/yr includes 312, 313 and 314
2	313	Assess spore viability and germination requirements.	2	4	TE	PRDNER, Universities, and Conservation Organizations				
2	314	Evaluate gametophyte establishment and growth, the requirements for fertilization and sporophyte establishment and growth.	Cont.	4	TE	PRDNER & Universities				
2	331	Assess feasibility of propagation.	2	4	TE	PRDNER & Universities	10	10		10/yr includes 331 and 332
2	332	Develop artificial propagation program.	2	4	TE	PRDNER & Universities				
2	411	Select sites and assess habitat suitability.	2-4	4	TE	PRDNER	No cost anticipated.			
2	412	Assure site protection.	2-4	4	TE	PRDNER	No cost anticipated			

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				REG	FWS DIV	OTHER	FY1	FY2	FY3	
2	413	Introduce and monitor plants.	2-4	4	TE	PRDNER & Universities	2	2	2	
2	51	Determine numbers of individuals and populations necessary to ensure species stability, security, and self-perpetuation.	Cont.	4	TE	PRDNER	No cost anticipated.			
2	52	Determine what additional actions, if any, are necessary to achieve recovery objectives.	Cont.	4	TE	PRDNER	No cost anticipated			

LIST OF ABBREVIATIONS:

PRDNER - Puerto Rico Department of Natural and Environmental Resources
 TE - Fish and Wildlife Service, Endangered Species Division
 LE - Fish and Wildlife Service, Law Enforcement Division

PART IV. LIST OF REVIEWERS

Dr. Pedro Gelabert
Secretary
Department of Natural and Environmental Resources
P.O. Box 5887
San Juan, Puerto Rico 00906

Dr. George Proctor
Botanist
Department of Natural and Environmental Resources
P.O. Box 5887
San Juan, Puerto Rico 00906

Mr. José Chabert
Terrestrial Ecology Section
Department of Natural and Environmental Resources
P.O. Box 5887
San Juan, Puerto Rico 00906

Mr. Peter Ortíz
Natural Heritage Program
Department of Natural and Environmental Resources
P.O. Box 5887
San Juan, Puerto Rico 00906

Mr. Edgardo González
Forest Service Area
Department of Natural Resources
P.O. Box 5887
San Juan, Puerto Rico 00906

Dr. Daniel Altschuler
Arecibo Observatory
P.O. Box 995
Arecibo, Puerto Rico 00613

Ms. Doris Betancourt
Acting Director
Department of Biology
Mayaguez Campus - UPR
P.O. Box 5000
Mayaguez, Puerto Rico 00681

Ms. Ana María Vera
Fundación Puertorriqueña de Conservación
Calle O' Neill Number 11
Hato Rey, Puerto Rico 00918

James D. Ackerman (*)
Director,
Department of Biology
University of Puerto Rico
P.O. Box 23360
San Juan, Puerto Rico 00931-3360

Dr. Pedro Acevedo (*)
Department of Botany
National Museum of Natural History
Smithsonian Institution
Washington, D.C. 20560

Dr. Henri E. Liogier (*)
Taxonomist
Botanical Garden - UPR
P.O. Box 364984
San Juan, Puerto Rico 00936-4984

Dr. Ariel Lugo
Institute of Tropical Forestry
U.S. Forest Service
Call Box 25000, Experimental Station
Río Piedras, Puerto Rico 00928

Ms. Peggy Olwell
Center For Plant Conservation
Missouri Botanical Garden
St. Louis, Missouri 63166-0299

Ms. Dena Garvue
Curator of Endangered Species
Fairchild Tropical Garden
11935 Old Cutler Road
Miami, Florida 33156-4299

Environmental Protection Agency
Hazard Evaluation Division - EEB (TS769C)
401 M Street, SW.
Washington, D.C. 20460

(*) - PEER REVIEWERS