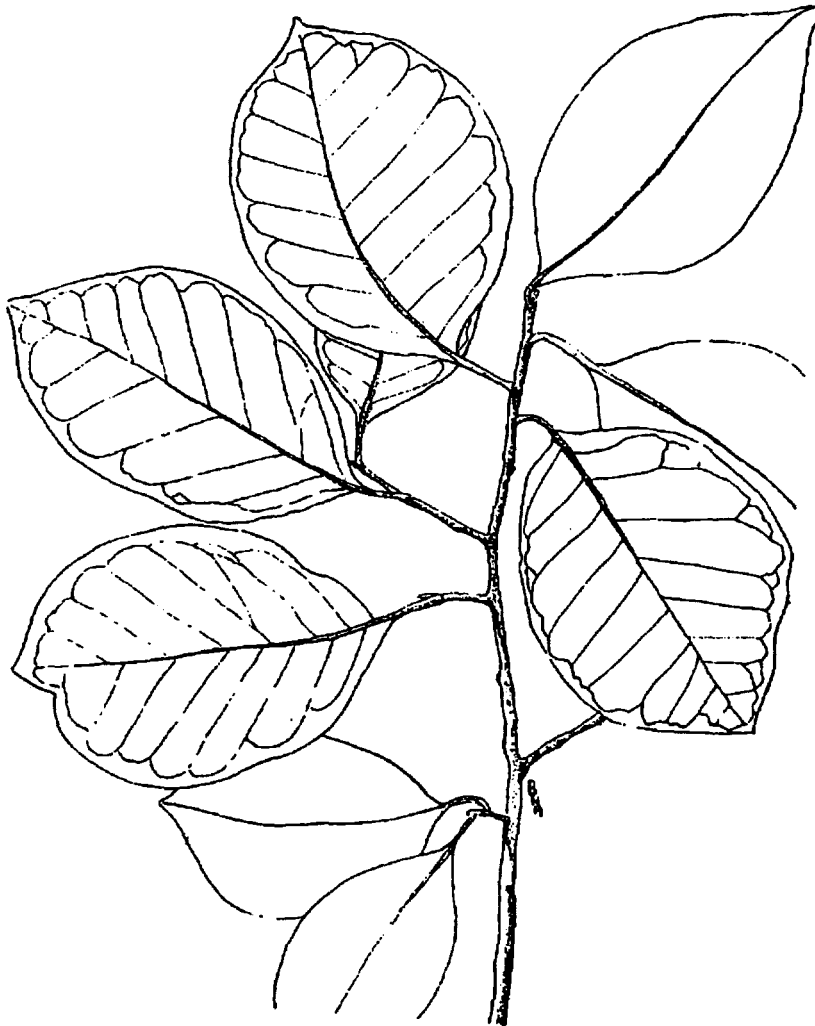


RECOVERY PLAN

PALO DE ROSA

(Ottochulzia rhodoxylon)



U.S. Fish and Wildlife Service
Southeast Region

OTTOSCHULZIA RHODOXYLON (PALO DE ROSA) RECOVERY PLAN

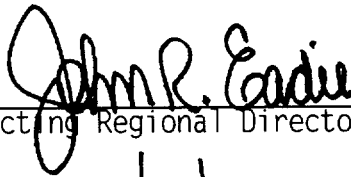
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Approved:



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

Date:

9/20/94

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. *Ottoschulzia rhodoxylon* (palo de rosa) Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 27 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: *Ottoschulzia rhodoxylon* (palo de rosa), a small tree endemic to Puerto Rico and Hispaniola, is listed as endangered. Approximately 200 individual trees are known from 16 populations in 10 areas.

Habitat Requirements and Limiting Factors: Palo de rosa is known from serpentine and limestone-derived soils in western Puerto Rico. In these areas, narrow moisture tolerance range has been identified. In Guánica it is found in the more humid canyon bottoms and in Quebradillas/Isabela it occurs on the drier upper slopes and summits. Deforestation for urban, commercial, and industrial development, and the extraction of limestone for construction material, have reduced and fragmented forested areas in Puerto Rico. Available information indicates that palo de rosa was cut frequently for fenceposts and for the use of the valuable reddish-colored wood.

Recovery Objective: Delisting.

Recovery Criteria: The 16 existing populations and their habitats should be protected.

Actions Needed:

1. Protect habitat, through acquisition or conservation easements, for existing privately owned populations and through the development of management plans for the species where it occurs on Federal or Commonwealth land.
2. Monitor known populations and continue to search for additional ones.
3. Continue to conduct research on the life history of the species and evaluate the necessity and feasibility of propagation.
4. If determined to be necessary and feasible, conduct propagation and enhance existing populations or establish new ones.

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

Recovery Costs: Recovery costs for *Ottoschulzia rhodoxylon* have been estimated to be \$102,500 for the first 3 years. Costs for land acquisition have not been estimated, since alternative mechanisms may be utilized to protect the species. Subsequent expenditures will depend upon the results of these preliminary studies, and therefore, cannot be estimated at this time.

TABLE OF CONTENTS

	Page
PART I. INTRODUCTION.	1
Description	1
Distribution/Population Status	2
Reproductive Biology.	4
Population Structure and Dynamics	6
Habitat Description	8
Reasons for Listing11
Conservation Measures11
PART II. RECOVERY	
A. Recovery Objective13
B. Outline Narrative.14
C. Literature Cited20
PART III. IMPLEMENTATION SCHEDULE.21
PART IV. LIST OF REVIEWERS.27

PART I. INTRODUCTION

Ottoschulzia rhodoxylon (palo de rosa) is a small evergreen tree which may reach up to 15 meters in height and 41 centimeters in diameter. Palo de rosa is endemic to Puerto Rico and Hispaniola, where it is also known to be rare. Approximately 191 individuals are known from 13 populations in seven areas of western Puerto Rico: Guaynabo; Quebradillas/Isabela; the Sierra Bermeja in Cabo Rojo; the Guánica Commonwealth Forest; the Susúa Commonwealth Forest; the Cambalache Commonwealth Forest; and the Maricao Commonwealth Forest. Urban, industrial and agricultural expansion has greatly reduced and fragmented forested areas in Puerto Rico. In addition, observations and available information indicate that the majority of individuals may have been cut in the past, possibly for fenceposts or for use of the species' attractive reddish-colored wood.

Ottoschulzia rhodoxylon was determined to be an endangered species on April 10, 1990 (U.S. Fish and Wildlife Service 1990). Critical habitat has not been designated for this species because of the risks of overcollecting and vandalism.

Description

Ottoschulzia rhodoxylon (palo de rosa) is a member of the Icacinaceae or the Icacina family. This genus, restricted entirely to the Greater Antilles, includes only three species (*O. rhodoxylon*, *O. domingensis* in Hispaniola, and *O. cubensis* in Cuba) and was dedicated to Otto Eugen Schulz, a German botanist (Liogier and Martorell 1982). Palo de rosa is known from only Hispaniola and Puerto Rico. In Hispaniola it has been described as rare (Liogier 1982). Only one specimen which has been identified as *O. rhodoxylon* has been found in the Botanical Garden of Santo Domingo (Breckon and Kolterman 1993). Palo de rosa was first collected by Leopold Krug near Mayagüez, Puerto Rico, in 1876 and was described in 1908. Today, a total of approximately 191 individuals in 13 populations have been located in western Puerto Rico.

Ottoschulzia rhodoxylon is a small evergreen tree which has been reported to reach 15 meters in height and 41 centimeters in diameter. The average height of 178 trees measured was 6.21 meters and the average diameter was 8.94 centimeters (Breckon and Kolterman 1993). The leaves are alternate, glabrous, and elliptic to ovate. They are from 5 to 9 centimeters long and 3 to 6 centimeters wide, rounded or blunt at the apex and the base, entire, thick and leathery. Flowers have only recently been observed (May 1993), but have not yet been described in the botanical literature (Breckon and Kolterman 1993). Flowers in this genus are bisexual, solitary or in clusters at the leaf bases, and composed of a cup-shaped corolla tube with five lobes (Little *et al.* 1974). The fruit is a one-seeded drupe with a thin pericarp (G. Proctor, pers. comm.). The heartwood is reddish, as is indicated by both the scientific and Spanish common name, and is suitable for articles of turnery.

Distribution/Population Status

Approximately 200 individuals of palo de rosa are known from 16 populations in the following areas in Puerto Rico: Guaynabo; Quebradillas/Isabela; Cambalache Commonwealth Forest; Guánica Commonwealth Forest; Maricao Commonwealth Forest; Susúa Commonwealth Forest; and the Sierra Bermeja in Cabo Rojo (Figure 1). The known sites may be described as follows:

1. Guánica Commonwealth Forest, Guánica and Yauco municipalities. Three populations (28 individuals) are known from this forest, which is managed by the Puerto Rico Department of Natural Resources.
 - a. Las Cóbanas Trail, Yauco municipality. Seven individuals occur along a canyon to the north of Las Cóbanas trail; the canyon drains towards the Yauco River.
 - b. Murciélagos Canyon, Guánica and Yauco municipalities. Five individual trees have been located in this canyon, which drains into the Caribbean Sea to the south of the Forest.
 - c. Hoya Honda Canyon, Guánica municipality. Sixteen trees occur along this canyon, which drains into the Caribbean Sea. Reproduction in the form of seedlings has been observed.
2. Sierra Bermeja, Cabo Rojo municipality. One tree has been identified from this privately owned range of hills in southwestern Puerto Rico. No reproduction has been observed.
3. Susúa Commonwealth Forest, Yauco and Sabana Grande municipalities. A total of 95 individuals have been identified from three different canyons in the forest, managed by the Puerto Rico Department of Natural Resources. No reproduction has been observed.
 - a. Quebrada Grande, Yauco municipality. Fifty-nine trees have been located along this stream bed. No reproduction has been observed.
 - b. Río Loco, Yauco municipality. Three discrete groups are found in this population: two isolated trees and a group of 23 trees occurring on the south side of the river. No reproduction has been observed.
 - c. Quebrada Peces, Sabana Grande municipality. Eleven individual trees have been located on the east-southeast facing slope of the stream. No reproduction has been observed.

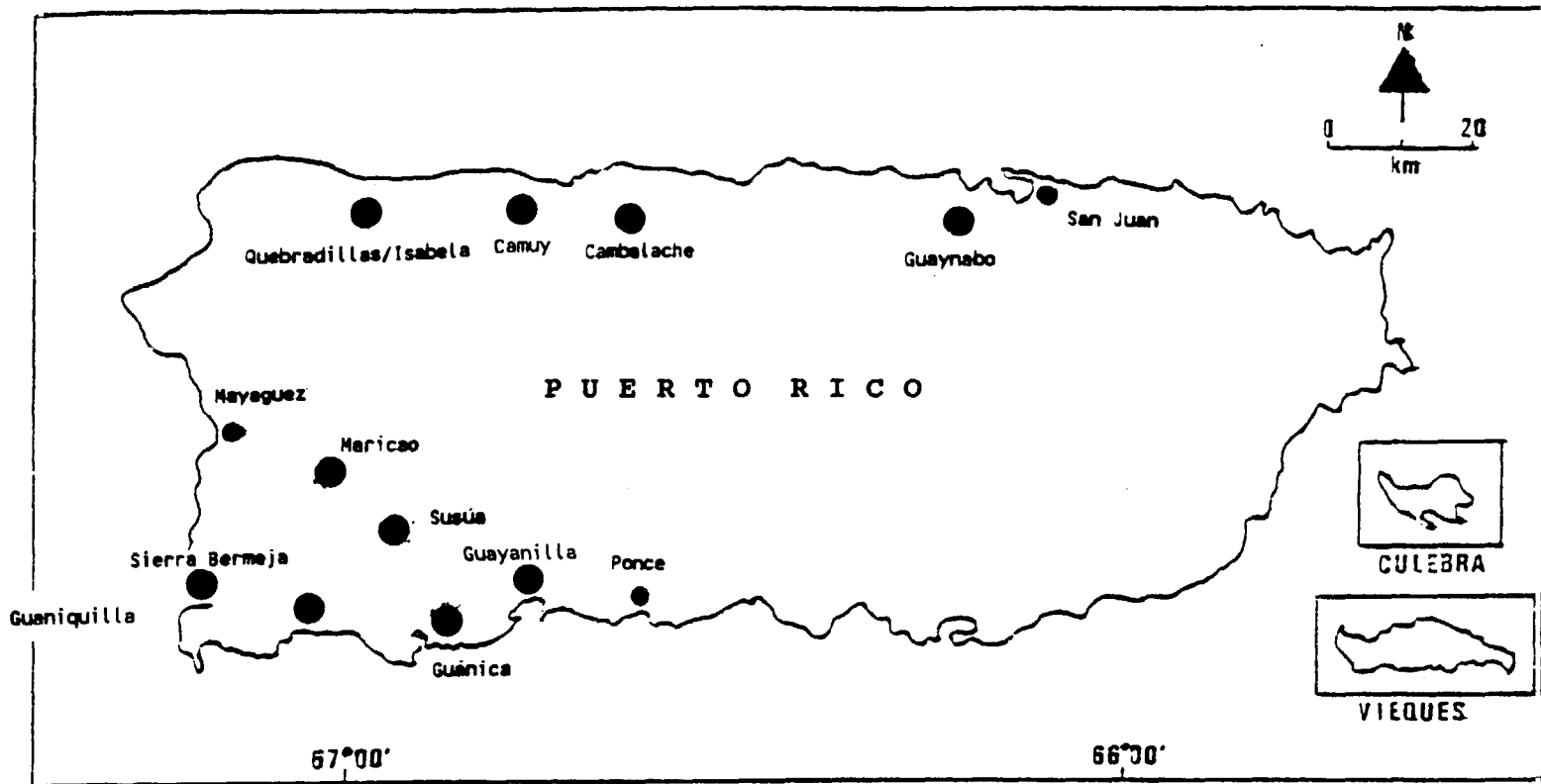


Figure 1. Locations (●) of known populations of Ototoschulzia rhodoxylon in Puerto Rico.

4. Quebradillas/Isabela populations, Quebradillas and Isabela municipalities. The species is found in three areas from which a total of 39 individuals have been identified. All are on privately owned land.
 - a. El Costillar mogote, Isabela municipality. A total of 14 trees occur in this population, located on a limestone hill called El Costillar which is on the south side of the Quebrada La Sequía near its junction with the Guajataca River. Seedlings have been found under two trees.
 - b. El Túnel, Isabela municipality. Twenty-four individuals have been located on the north-facing slope of the cliffs bordering the old railroad right-of-way. Few seedlings were located under several trees.
 - c. Río Guajataca, Quebradillas municipality. One individual has been located near the Guajataca River.
5. Maricao Commonwealth Forest, San Germán municipality. One individual has been located in this forest, an area which is managed by the Puerto Rico Department of Natural Resources. The tree has been observed in flower but no seeds have formed.
6. Cambalache Commonwealth Forest, Arecibo municipality. A total of 15 trees have been located in this Forest, located in the limestone hills of northern Puerto Rico. The Forest is managed by the Puerto Rico Department of Natural Resources. No reproduction has been observed.
7. Fort Buchanan, Guaynabo municipality. Twelve trees were located in the limestone hills of the U.S. Army installation, Fort Buchanan, located just to the west of San Juan.
8. Cedro Ward, Guayanilla municipality. A large population has recently been discovered in this area (D. Kolterman and G. Breckon, pers. comm.)
9. Pedernales Ward, Punta Guaniquilla, Cabo Rojo municipality. Two trees have recently been located (D. Kolterman and G. Breckon, pers. comm.)
10. Camuy municipality. Five to six trees have been recently been located (D. Kolterman and G. Breckon, pers. comm.).

Reproductive Biology

The flowers and fruit of *Ottoschulzia rhodoxylon* or palo de rosa have only recently been observed. The fruit has been described as a one-seeded drupe with a thin pericarp (G. Proctor, pers. comm.). Fruit was observed

on one tree in Guánica in 1985 (G. Proctor and R. Woodbury, pers. comm.) and again in September of 1991 in Isabela (El Costillar) (Breckon and Kolterman 1992). Flowers, small and pale greenish-white in color, were observed for the first time in the population at Isabela (El Costillar) and on the tree in the Maricao Forest in May 1993 but have not yet been described in the botanical literature (Breckon and Kolterman 1993).

Because so little information has been obtained, due to the apparent infrequency of flowering and fruiting, it has not been possible to describe any pattern of flowering or fruiting for the species. Flowering has only been observed in May 1993, in Isabela (El Túnel population) and in July 1993, on the one known tree in the Maricao Commonwealth Forest. Although it has been suggested that the cutting of individuals and their subsequent sprouting may maintain individuals in a permanently juvenile condition, the limited data available do not support this. Buds and/or flowers were observed on six trees in Isabela and one tree in Maricao. The one tree in Maricao and two of those in Isabela had not been cut; however, four showed evidence of having regenerating after having been cut. In addition, four of the six trees beneath which seedlings have been found also showed evidence of having been cut in the past. The seven individual trees observed with flowers ranged in height from 3.0 to 11.5 meters and in basal diameter from 4.8 to 35.8 centimeters. Preliminary observations indicate that *Ottoschulzia rhodoxylon* may be a mast flowering species, one that produces large number of fruit in some years but few or none in other years. Limited data suggest that flowering may be associated with new leaf production (Breckon and Kolterman 1993).

Breckon and Kolterman (1993) monitored the progress of flower development on the six trees in Isabela. Only one or two flowers per branch were open at any one time. By July 1993, all flower buds and open flowers had abscised. No fruit was set on any of the trees monitored. Although insect damage was observed on a few buds, they speculate that low rainfall may be the cause of the flower bud abortion. Preliminary observations on the flowering tree in Maricao indicate that, although no abscission of buds had occurred, no fruit had been produced.

The stigma of several flowers were examined, and although the anthers form an arch over the stigma, no pollen was located. This, combined with the lack of fruit set on that the isolated tree in Maricao, indicates that palo de rosa may be an outcrossing (requires cross pollination between individuals) species. Visitation to flowers by possible pollinators has not been observed; however, additional observations are necessary (Breckon and Kolterman 1993).

The fruits of palo de rosa are drupes similar in size, morphology, and color to fruits of *Andira inermis* (moca) and *Calophyllum brasiliense* (maría) which are bat dispersed, suggesting that fruits of palo de rosa may also be disseminated by bats. The existence of isolated trees supports this suggestion (Breckon and Kolterman 1993).

Population Structure and Dynamics

Data on population size and structure from the Guánica, Susúa, Maricao, Isabela/Quebradillas, and Cambalache populations are summarized in Table 1 (from Breckon and Kolterman 1993). A high proportion of trees showing evidence of having been cut in the past was found in all areas except for Maricao (only one tree present): 37 percent in Guánica; 47 percent in Susúa; 67 percent in Isabela; and 60 percent in Cambalache. Within these areas the more accessible populations and groups were more frequently cut than those not as accessible.

With the exception of the isolated tree in Maricao, mean stem diameter (the largest main stem was measured in multitrunked trees) was greatest in the Guánica populations. The largest trees in Guánica, reaching 41 centimeters in diameter (and of which only 19 percent had been cut), were found in Hoya Honda, an inaccessible area from which tree removal would have been difficult. Mean plant height was also greatest in Guánica, where trees reached heights of as much as 15 meters (Breckon and Kolterman 1992, 1993).

The populations in Guánica, Susúa, and Isabela were similar in size class distribution and the pattern of dispersion. Most individuals were clustered, but scattered solitary trees were found (Breckon and Kolterman 1992). These authors suggested that root sprouts might be responsible for this aggregated pattern. Because most trees were in the intermediate size class, with only a few larger and smaller individuals, it possible that populations may consist of groups from several different reproductive events. Seedlings and/or saplings were found beneath trees in Guánica (Las Cóbanas), Susúa (Quebrada Grande), and Isabela (El Túnel and El Costillar). The largest number of seedlings (approximately 1,000) was found beneath trees in the El Costillar population in Isabela. Fifteen permanent quadrants (1 m x 1 m) were established in December 1991, in order to follow seedling survival and recruitment. Of 156 seedlings located within the quadrants, 141 or 90 percent survived as of July 1993. In addition, new individuals were observed in the study plots. The latter occurrence may be due to long viability of the seeds in the soil and their subsequent germination, unreported erratic seed production, or human error (Breckon and Kolterman 1993).

Preliminary seed germination experiments indicate that seeds germinate easily under semi-shady, mesic conditions. There is no evidence of dormancy (Breckon and Kolteran 1993).

Leaf morphometric studies indicate that leaves in the more mesic serpentine Susúa (Río Loco) population were thicker than those in the limestone (El Costillar) Quebradillas/Isabela population and that, as would be expected, leaf thickness increased from full shade to full sun conditions (Breckon and Kolterman 1993). This type of study, as well as electrophoresis (initiated in 1993), will provide information on genetic diversity of the populations and identify which populations and individuals should be propagated in order to preserve the genetic diversity of the species.

Table 1. Population size and structure for *Ottoschulzia rhodoxylon* in western Puerto Rico. In some populations small saplings were observed but not labeled or measured. Sample size is not always equal to population size due to missing data (from Breckon and Kolterman 1993).

Population	Population Size	Plant Height (m)			Main Stem Diameter (cm)			% Cut	Seedlings	Saplings	Elevation (m)
		range	mean	s. d.	range	mean	s. d.				
GUANICA	28	1.5-15.0	8.31	3.96	2.0-41.0	15.39	11.46	37			
Las C6barras	7	2.3-13.0	7.39	3.35	3.2-17.1	8.97	5.37	71	yes	no	18-35
Murci6lagos	5	8.0-15.0	11.20	2.50	12.8-31.5	21.88	6.13	50	no	no	55-62
Hoya Honda	16	1.5-15.0	7.81	4.16	2.0-41.0	16.18	13.18	19	no	no	60-75
SUSUA	95	0.5-12.0	5.65	2.70	1.2-20.0	6.33	3.90	47			
Quebrada Grande	59	0.5-12.0	5.50	2.90	1.2-20.0	6.36	4.28	47	no	yes	160-170
R6o Loco	25	1.5-11.0	5.72	2.35	1.5-15.0	6.26	3.24	61	no	no	145-150 (175)
Quebrada Peccas	11	3.0-9.3	6.30	2.20	2.0-11.5	6.31	2.99	18	no	no	ca. 200
MARICAO	1	11.5			21.0			0	no	no	625
ISABELA	39	2.0-11.0	5.46	2.13	1.9-35.3	10.75	7.63	67			
El T6nel	24	2.0-11.0	4.86	1.98	3.0-35.3	12.28	8.27	75	yes	yes	20-40
El Costillar	14	3.5-11.0	6.50	2.07	1.9-20.5	8.73	5.64	57	yes	yes	80-90
R6o Guayanaca	1	5.0			2.5			0	no	no	10
CAMBALACHE	15	1.0-13.5	7.42	3.32	3.0-14.6	7.95	4.42	60	no	no	70-112
TOTAL	178	0.5-15.0	6.21	3.09	1.2-41.0	8.94	7.41	50			

Habitat Description

Ottoschulzia rhodoxylon is known from thirteen populations in seven areas in western Puerto Rico. Although widely separated, similar characteristics have been identified. In general, trees are limited to well-drained, alkaline, rocky soils derived from limestone or serpentine, as are trees of the other two members of the genus in Cuba and Hispaniola. In both Guánica and the Sierra Bermeja, palo de rosa is restricted to the bottom of canyons, where conditions are more mesic than might be expected given the extremely low annual precipitation. In Susúa, with greater rainfall than Guánica, the populations are restricted to the lower slopes of the mesic ravines. In the limestone hills of the north coast, receiving more precipitation than Guánica or Susúa, palo de rosa occurs on the upper slopes and near the summits, where more xeric conditions prevail. Trees, therefore, are found in drier habitats (upper slopes and summits of hills) in the more mesic northern limestone hills and more mesic habitats (canyon bottoms) in the dry forests of Guánica and the Sierra Bermeja, an indication of a narrow range of moisture tolerance (Breckon and Kolterman 1992, 1993).

Guánica Commonwealth Forest

The Guánica Commonwealth Forest is located in southwestern Puerto Rico in the subtropical dry forest life zone (Ewel and Whitmore 1973). This is the driest life zone of Puerto Rico and covers about 14 percent of the island area. The forest was designated as a forest reserve in 1919 and a United Nations Biosphere Reserve in 1981. Mean annual precipitation in the Guánica area is approximately 79 centimeters. Over 55 percent of the precipitation falls during the wetter season, from August through November. The dry season extends from January through March. Mean annual temperature has been reported to be 25.3°C with a mean monthly minimum of 23.5°C and a mean monthly maximum of 26.7°C (Silander *et al.* 1986). The Forest is underlain by limestone sedimentary rocks, Tertiary in origin, and outcrops cover much of the area. Soils are derived from limestone and are shallow, well-drained, and alkaline in nature. Limestone outcrops cover much of the area.

The Guánica Forest supports a variety of vegetation types including cactus scrub, littoral forest, deciduous forest, and semi-evergreen forest. Palo de rosa is found in the semi-evergreen forests of the bottoms of the more mesic canyons (at elevations ranging from 18 to 75 meters). In these canyons trees are taller, often reaching 15 meters, and a larger number of evergreen species are found. Silty alluvial soils, which retain a greater moisture content, are found among large limestone rock outcrops in these drainages. Water runs through these canyons during heavy rainfall but the remainder of the year they are dry. Associated species in this vegetation type are *Guaiacum officinale* (guayacán); *G. sanctum* (guayacán blanco); *Coccoloba diversifolia* (cucubano); *Bucida buceras* (úcar); *Bursera simaruba* (almácigo); *Eugenia rhombea* (guayabilla de costa); and *E. maleolens* (anguila). The proposed endangered *Eugenia woodburyana* and the endangered *Trichilia triacantha* is found in this same locality.

Sierra Bermeja

The Sierra Bermeja is a range of low hills (reaching an elevation of approximately 300 meters) in southwestern Puerto Rico. Soils have been described as Guayama cherty clay loam, a soil series which covers most of the ranges steep slopes. The climatic regime is similar to that described above for the Guánica Commonwealth Forest. The individual tree is located at an elevation of approximately 125 meters and, as in Guánica, at the bottom of a canyon.

Susúa Commonwealth Forest

The Susúa Commonwealth Forest, located on the lower slopes of the central mountains in southwestern Puerto Rico, occurs within the subtropical moist forest life zone (Ewel and Whitmore 1973), the most extensive life zone on the island. Mean annual precipitation near the Susúa Forest has been reported to be 1339 millimeters with a dry season occurring from January to March and a wetter period from July to November (Silander *et al.* 1986).

Soils (Nipe and Rosario series) are derived from serpentine rock, which is Cretaceous in origin and black to pale green, soft, friable and contain high amounts of olivine, clinopyroxene, and orthopyroxene. Serpentine soils are alkaline, very well-drained, nutrient deficient, and often have high levels of toxic elements such as nickel and cobalt. The poorly developed and well-drained nature of the soils result in a more xeric vegetation type than might be expected from the climatic regime.

Much of the vegetation in the Susúa Forest was cut for cultivation, grazing, charcoal production, and wood prior to its designation as a public forest. Three habitat types have been described within the forest: ravines or gullies, slopes, and summits. A gradient from mesic to xeric extends from the ravines to the summits. Palo de rosa is found on the middle to lower slopes at elevations between 145 and 200 meters. The vegetation may be described as a low semi-evergreen forest (about 12 meters in height) composed of sclerophyllous evergreen and deciduous species. The three populations are found in three separate canyons, all of which are part of the Río Loco drainage. Associated species include, among others, *Calophyllum brasiliense* (maría); *Clusia rosea* (cupey); *Lonchocarpus latifolius* (hediondo); *Diospyros sintenisii*; *Pisonia albida* (corcho); and *Amyris elemifera* (tea). *Zamia portoricensis* was found in the understory. The endangered *Crescentia portoricensis* often co-occurs with *Ottoschulzia rhodoxylon* in Susúa. Both species are more abundant there than elsewhere in the forest, perhaps because ravines were less disturbed than slopes and summits (D. Kolterman, pers. comm.).

Cambalache Commonwealth Forest

The Cambalache Commonwealth Forest is located in the limestone hills on the northern coast of Puerto Rico in the municipalities of Barceloneta and Arecibo. The forest overlies the Aymamón and Aguada limestone. Annual precipitation at the Cambalache Experimental Station was 1295 millimeters

with wetter periods occurring from September through December and again in May. The drier period occurs from January through March and June through August. Mean annual temperature was 25.4°C with a mean minimum monthly temperature of 23.5°C in January and a maximum of 26.9°C during August.

The Cambalache Commonwealth Forest lies within the subtropical moist forest life zone (Ewel and Whitmore 1973). Three plant associations have been identified and include slopes, hilltops, and valleys. The hilltops tend to be drier while gentle north-facing slopes and steep southwest facing slopes are more humid. Valleys, while the most humid area, tend to be disturbed and support plantations or secondary growth. The plants which have been identified in Cambalache occur at elevations of 70 to 112 meters. Associated species may include *Coccoloba diversifolia* (cucubano); *Ardisia obovata* (mameyuelo); *Dipholis salicifolia* (alendrón); and *Terebraria resinosa* (aquilón).

Maricao Commonwealth Forest

The Maricao Commonwealth Forest, consisting of two major segments, is located in western Puerto Rico in the municipalities of Mayagüez, San Germán, Maricao, and Sabana Grande. Elevations reach 875 meters. Most of the forest overlays serpentine rock, Cretaceous in origin, black to pale green, soft, friable and containing high amounts of olivine, clinopyroxene, and orthopyroxene. Serpentine soils are alkaline, very well-drained, nutrient deficient, and often have high levels of toxic elements such as nickel and cobalt. The poorly developed and well-drained nature of the soils result in a more xeric vegetation type than might be expected from the climatic regime.

Mean annual precipitation at two stations near the forest is 2326 millimeters (Maricao 255 west, elevation 863.2) and 2466 millimeters (Maricao Fish Hatchery, elevation 457 meters). Mean annual temperature at the first station was 21.7°C, with a mean minimum monthly temperature of 20.2°C in January and a maximum of 23.0°C in August.

The Maricao Forest falls within three life zones: subtropical wet forest, subtropical rain forest, and subtropical lower montane wet forest (Ewel and Whitmore 1973). The known tree of palo de rosa falls within the subtropical wet forest and is located at an elevation of about 625 meters. Associated plant species include *Buchenavia capitata* (granadillo); *Calophyllum brasiliense* (maría); *Clusia clusioides*; *C. rosea* (cupey); *Neolaugeria resinosa* (aquilón); *Pimenta racemosa* var. *grisea* (malagueta); *Pisonia albida* (corcho); *Podocarpus coriaceus* (caobilla); and *Thouinia striata* (quiebrahacha). This area has lower temperatures, higher humidity, and more precipitation than the other areas where palo de rosa is found (Breckon and Kolterman 1993).

Quebradillas/Isabela

The Quebradillas/Isabela populations occur in the subtropical moist forest life zone (Ewel and Whitmore 1973). The area is underlain by limestone, Miocene in origin. Soils are limestone derived, well-drained,

and alkaline in nature. Limestone rock outcrops are frequent on the surface.

As in other limestone hill areas a moisture gradient from wetter to drier occurs from the valley bottoms to the hilltops. Palo de rosa is found on the upper slopes and summits of the hills. Associated species include, among others, *Bursera simaruba* (almácigo); *Coccoloba diversifolia* (cucubano); *Eugenia ligustrina*; *E. maleolens*; *Gaussia attenuata*; *Comocladia glabra* (carrasco); *Guapira fragrans*; *Krugiodendron ferreum*; *Maytenus laevigata*. The proposed endangered *Auerodendron pauciflorum* and the endangered *Peperomia wheeleri* and *Zanthoxylum thomasianum* are known from the population sites.

Reasons For Listing

Ottoschulzia rhodoxylon was listed as endangered in 1990. At the time of its listing it was known from only nine individuals in three locations: Guánica Commonwealth Forest; Maricao Commonwealth Forest; and an area to the west of San Juan. Forested areas on both the north and south coasts have been eliminated and fragmented for residential, urban, commercial and tourist developments. Indeed, entire limestone hills are being removed in order to use the material in construction. In addition, the species was apparently extensively utilized for posts and for its valuable reddish-colored wood.

Following the listing, studies of the distribution, abundance and reproductive biology were initiated through Cooperative Agreements between University of Puerto Rico at Mayagüez and the U.S. Fish and Wildlife Service (Service). As a result of these studies, new individuals and populations were discovered. Flowers, not previously described in the scientific literature, were located. Nevertheless, despite the discovery of additional individuals, fewer than 200 trees are presently known. One of the largest populations, and the one known to reproduce most successfully, is found on privately owned land which, until recently, was the subject of a proposal for a large tourist development. The area continues to be under intense pressure for development. The Sierra Bermeja, also privately owned, is threatened by residential and tourist development and agricultural activities. Only one tree is known from this location, and will probably not reproduce. Although several populations are found on public land (i.e., Commonwealth Forests), these lack management plans and, therefore, management activities could adversely affect the species.

Conservation Measures

Studies of the distribution, abundance, population size and structure, and reproductive biology of palo de rosa have been ongoing since 1991 through the above-mentioned Cooperative Agreements. As a result of these studies, new individuals and populations have been located, flowers have been described for the first time, seedling survival is being monitored, and electrophoresis, leaf morphometrics, and germination studies have been initiated (Breckon and Kolterman 1992, 1993). These studies have

provided insight into the possible reasons for the rarity of the species and recommendations for its recovery. Preliminary results from these studies have been incorporated into this recovery plan.

Following the listing of the species as endangered by the Service, the Puerto Rico Department of Natural and Environmental Resources also protected the species through its Regulation which Governs the Management of Vulnerable and Endangered Species. The Department, as well as the Service, has considered the species in recent proposals for the development of a large, ambitious hotel/golf course complex in Isabela. Although the project is not currently active, the Service and the Department worked closely with the developer in order to establish conservation easements which would protect palo de rosa, as well as other endangered plants and animals. The U.S. Army is currently funding surveys of *Ottoschulzia rhodoxylon*, and other endangered species, on the Fort Buchanan installation.

PART II. RECOVERY

A. Recovery Objective

The objective of this recovery plan is to restore *Ottoschulzia rhodoxylon* to a self-sustaining status, thereby permitting it to be eventually removed from the Federal Endangered Species List.

Ottoschulzia rhodoxylon could be considered for delisting when (1) populations known to occur on privately owned land are placed under protective status, (2) an agreement between the Service and the U.S. Army concerning the protection of the species on their land (Fort Buchanan) has been prepared and implemented, and (3) mechanisms for protection of palo de rosa have been incorporated into management plans (currently not existing for all forests) for the Maricao, Guánica, Susúa, and Cambalache Commonwealth Forests. Given the recent discovery of additional populations, priority should be given to the enhancement and protection of existing populations in protected areas and the protection of privately owned sites.

B. Outline Narrative

1. Prevent loss of habitat and populations.
Habitat protection at the known population sites, both on private and public lands, should be considered to be a priority for the appropriate public agencies.
11. Protect habitat.
Highest priority should be given to the protection of existing populations.
 111. Provide protection for privately owned population sites.
The Sierra Bermeja and the Quebradillas/Isabela populations are found on privately owned land. Protection may be provided to these populations through acquisition, conservation easements, or landowner agreements. Efforts were initiated (Service, PRDNER, and developer) to develop easements for a hotel/resort complex in Isabela.
 112. Develop managements plans for the Guánica, Susúa, Maricao, and Cambalache Commonwealth Forests.
Management plans should be developed for the Guánica, Susúa, Maricao, and Cambalache Commonwealth Forests. These plans should include measures to protect the known population sites and individual plants. In addition, growth and reproduction should be monitored on a long-term basis.
 113. Incorporate, in cooperation with the U.S. Army, into Fort Buchanan's existing land use management plan provisions for protection of palo de rosa.
Protection should be assured for the small population recently found in the limestone hills of Fort Buchanan.
12. Protect plants.
A total of 178 of the 191 known trees have been marked and measured. These trees should continue to be monitored on a long-term basis.
 121. Continue to monitor known populations.
Individual plants have been measured and marked at five of the seven known areas and seedling plots have been established at the El Costillar population in Quebradillas/Isabela. Trees

should be marked and measured at the Fort Buchanan site, as part of their recently funded endangered plant surveys. Basic field observations which will contribute to the information available on population behavior (including phenology, seed production, seed dispersal, recruitment success, site changes, and growth) should be made at regular intervals. This long-term monitoring may be incorporated into the Commonwealth Forest management plans.

122. Enforce existing Federal and Commonwealth endangered species regulations.

The Commonwealth Department of Natural and Environmental Resources' Regulation to Govern the Management of Threatened and Endangered Species of 1985 provides for criminal penalties for illegal take of listed plant species on public land. Development projects which occur on privately owned land may be funded through local or Federal agencies or require local permits. The Regulation's Section 10 provides for consultations on endangered species which may be affected by a particular project similar to Section 7 of the Endangered Species Act. A Section 7 consultation would be necessary for any action which might affect the species on the U.S. Army Fort Buchanan installation.

123. Incorporate *Ottoschulzia rhodoxylon* into existing education programs.

Both Federal (Service) and Commonwealth (PRDNER) agencies are involved in the education of the public on general conservation values as well as on the importance of protecting endangered plants and of adhering to Federal and local regulations. Palo de rosa should be included in the illustrated brochure and slide presentation on endangered plants and plant communities which is presented to local school groups and organizations and agencies. Permitting and funding agencies (those potentially involved in Section 7 consultations) should be made aware of endangered plants, the pertinent laws, and their responsibilities.

2. Continue to gather information on the distribution and abundance of *Ottoschulzia rhodoxylon* in western Puerto Rico.
Through Cooperative Agreements between the Service and the University of Puerto Rico, Mayagüez, new populations and individuals have been discovered. Information collected will be useful for future searches.
21. Continue to search for new populations.
Searches for new individuals and populations should be continued in western Puerto Rico.
 211. Identify and inventory potential sites.
Basic habitat characteristics have been identified by the University of Puerto Rico, Mayagüez Campus, studies. Utilizing this information, potential sites may be identified and inventoried. Agencies and organizations which should be involved in these efforts include the Fish and Wildlife Service, the Department of Natural and Environmental Resources (Forest Service and the Natural Heritage Program), local universities 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 database of the various agencies and organizations involved. In addition, sites should be evaluated for the availability of propagative material and the potential for protection.
3. Conduct research.
Ongoing research has provided additional information on distribution, abundance, population size and structure, and preliminary information on flowering and fruiting, germination, seedling survival, pollination, and dispersal. Such studies need to be continued in order to obtain a better understanding of the biology of palo de rosa.
 31. Continue to define habitat requirements.
Although ongoing studies have identified characteristics which are similar among the known population sites and would be useful for the identification of potential population sites, intensive studies of known sites may provide additional information.

32. Continue to study reproductive biology and ecology of palo de rosa.
Ongoing studies have identified areas where more intensive study is needed.
321. Continue to study periodicity of flowering, pollination mechanisms, problems with fruit set, and dispersal mechanisms.
Initial studies indicate that flowering and fruiting are relatively infrequent events. They also indicate that some reproductive events may be unsuccessful (abortion of buds and flowers in Quebradillas/Isabela and lack of fruit set in Maricao). Although there has been speculation as to the factors responsible, additional study is needed (environmental factors, pollinators). Dispersal agents, which may be bats, should be identified.
322. Continue to evaluate seed viability, longevity, and germination requirements.
Preliminary information suggests that seeds may remain viable for at least a year and a half on the forest floor. These same studies also indicate that germination in the laboratory occurs easily (Breckon and Kolterman 1993). Upon availability of seeds, an infrequent occurrence, further observations on germination in both the laboratory and the field should be made.
323. Continue to evaluate requirements for seedling establishment and growth.
Initial studies of seedling survival indicate that between December 1991, and August 1993, 90 percent of marked seedlings survived. Breckon and Kolterman (1992) speculate that due to the large size of the seed and the stored food, seedlings germinate beneath a closed forest canopy and persist until the stored food is utilized. Thus seedlings will survive if a gap in the forest canopy occurs prior to the exhaustion of food stores. Seedling plots should continue to be monitored and, upon discovery of additional seedlings, additional plots should be established.
324. Conduct studies of population genetics.
By means of electrophoresis and/or morphometric analysis of leaves, conduct studies of population genetics in order to identify

individuals and populations that must be propagated in order to preserve the genetic diversity of this rare plant.

33. Continue to evaluate necessity and feasibility of artificial propagation and include palo de rosa in existing propagation programs.
Due to the discovery of additional populations and individuals, the necessity for propagation as a recovery mechanism and whether new populations should be established or existing ones enhanced should be carefully evaluated. Because of the infrequency of the availability of seeds, alternate propagation techniques should be evaluated for use in existing propagation programs.
331. Assess necessity for artificial propagation.
Because of the discovery of additional populations in protected areas, the necessity for artificial propagation should be evaluated. In addition, whether the establishment of new populations or the enhancement of those existing is preferable should be discussed. An interagency group (Service, PRDNER, universities) should be formed to discuss this and other issues.
332. If determined to be necessary and feasible, incorporate palo de rosa into existing artificial propagation programs.
If determined to be necessary and feasible, this species should be included in the ongoing artificial propagation program at local nurseries (e.g., the Department of Natural and Environmental Resources).
333. Enhance existing populations or establish new populations.
If enhancement of existing populations is determined to be necessary and feasible, results of the above-mentioned research should be considered in order to assure the success and relevance of transplanting propagated material. Enhancement is needed particularly in the Sierra Bermeja and the Maricao areas, where only a single individual occurs. If the establishment of new populations is chosen as a recovery alternative, characteristics and protection should be considered in site selection.

4. Refine recovery goals.
As additional information on the biology, ecology, propagation, and management of *Ottoschulzia rhodoxylon* is accumulated, it will be necessary to better define, and possibly modify, recovery goals.
 41. Determine number of individuals and populations necessary to ensure species' stability and self-perpetuation.
Environmental and reproductive studies, including population genetics, together with the relative success of population protection measures, will allow more precise and realistic recovery goals to be established.
 42. Determine what additional actions, if any, are necessary to achieve recovery goals.
If there are any actions not included in this recovery plan which, during the recovery process become recognized species' needs, they must be incorporated into the plan.

C. Literature Cited and References

- Breckon, G. J. and D. A. Kolterman. 1992. *Ottoschulzia rhodoxylon* (Urban) Urban (Icacinaceae). Final Report under Cooperative Agreement No. 14-16-0004-91-958 between U.S. Department of the Interior, Fish and Wildlife Service and Department of Biology, University of Puerto Rico, Mayaguez Campus. 18 pp.
- Breckon, G. J. and D. A. Kolterman. 1993. *Ottoschulzia rhodoxylon* (Urban) Urban (Icacinaceae). Final Report under Cooperative Agreement No. 14-16-0004-92-970 between U.S. Department of the Interior, Fish and Wildlife Service and Department of Biology, University of Puerto Rico, Mayaguez Campus. 18 pp.
- Ewel, J.S. and J.L. Whitmore. 1973. Ecological life zones of Puerto Rico and the U.S. Virgin Islands. USDA - Forest Serv. Res. Paper ITF-18. 72 pp.
- Liogier, A. H. 1982. La flora de la Española. I. Universidad Central del Este, Serie Científica XII, Centenario de San Pedro de Macorís, Vol. VI, San Pedro de Macorís, Dominican Republic. 317 pp.
- Liogier, H.A. and L.F. Martorell. 1982. Flora of Puerto Rico and the Virgin Islands: a systematic synopsis. Editorial de la Universidad de Puerto Rico, Río Piedras, Puerto Rico. 342 pp.
- Little, E. L., Jr., R. O. Woodbury, and F. H. Wadsworth. 1974. Trees of Puerto Rico and the Virgin Islands. Volume 2. Agriculture Handbook No. 449. U.S. Department of Agriculture, Forest Service, Washington, D.C. 1,024 pp.
- Silander, S., H. Gil de Rubio, M. Miranda, and M. Vazquez. 1986. Los Bosques de Puerto Rico, Volume II. Compendio Enciclopédico de los Recursos Naturales de Puerto Rico. Puerto Rico Department of Natural Resources, San Juan, Puerto Rico.
- U.S. Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; determination of endangered status for the plant *Ottoschulzia rhodoxylon*. Federal Register Vol. 55:13491.

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.

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				FWS REGION	DIVISION	OTHER	FY1	FY2	FY3	
1	111	Provide protection for privately owned population sites.	4	4	TE	PRDNER				Cost cannot be determined at this time due to possibility of protection through conservation easements and/or landowner agreements.
1	112	Develop management plans for the Guánica, Susúa, Maricao and Cambalache Commonwealth Forests.	2-4	4	TE	PRDNER				No cost anticipated.
1	113	Incorporate, in cooperation with the U.S. Army, into Fort Buchanan's existing land use management plan provisions for protection of palo de rosa.	2	4	TE	Army PRDNER				No cost anticipated.
1	121	Continue to monitor known populations.	Cont.	4	TE	Univ. PRDNER	4	4	4	

IMPLEMENTATION SCHEDULE

PRIO- RITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				FWS			FY1	FY2	FY3	
				REGION	DIVISION	OTHER				
1	122	Enforce existing Federal and Commonwealth endangered species regulations.	Cont.	4	TE LE	PRDNER	9	9	9	One DNER ranger half-time
2	123	Incorporate Ottoschulzia rhodoxylon into existing education programs.	Cont.	4	TE	PRDNER	1	1	1	
2	211	Identify and inventory potential sites.	2-4	4	TE	PRDNER Univ.	2	2	2	
2	212	Characterize sites to determine their suitability as future recovery sites.	2-4	4	TE	PRDNER Univ.				
2	31	Continue to define habitat requirements.	2	4	TE	Univ. PRDNER	1.5	1.5	1.5	

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				FWS		OTHER	FY1	FY2	FY3	
				REGION	DIVISION					
2	321	Continue to study periodicity of flowering, pollination mechanisms, problems with fruit set, and dispersal mechanisms.	2-4	4	TE	Univ. PRDNER	10	10	10	10K/yr includes 321, 322, and 323.
2	322	Continue to evaluate seed viability, longevity and germination requirements.	2-4	4	TE	Univ. PRDNER				
2	323	Continue to evaluate requirements for seedling establishment and growth.	2-4	4	TE	Univ. PRDNER				
2	324	Conduct studies of population genetics.	2-4	4	TE	Univ.	3	3	3	
2	331	Assess necessity for artificial propagation.	2	4	TE	Univ. PRDNER				

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS
				FWS			FY1	FY2	FY3	
				REGION	DIVISION	OTHER				
2	332	If determined to be necessary and feasible, incorporate palo de rosa into existing artificial propagation programs.	Ongoing	4	TE	PRDNER Univ. BotGar	3	3	3	
2	333	Enhance existing populations or establish new populations.	4	4	TE	PRDNER Univ.			3	
2	41	Determine number of individuals and populations necessary to ensure species' stability and self-perpetuation.	Cont.	4	TE	PRDNER Univ.				
2	42	Determine what additional actions, if any, are necessary to achieve recovery goals.	Cont.	4	TE	PRDNER Univ.				

PART IV. LIST OF REVIEWERS

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