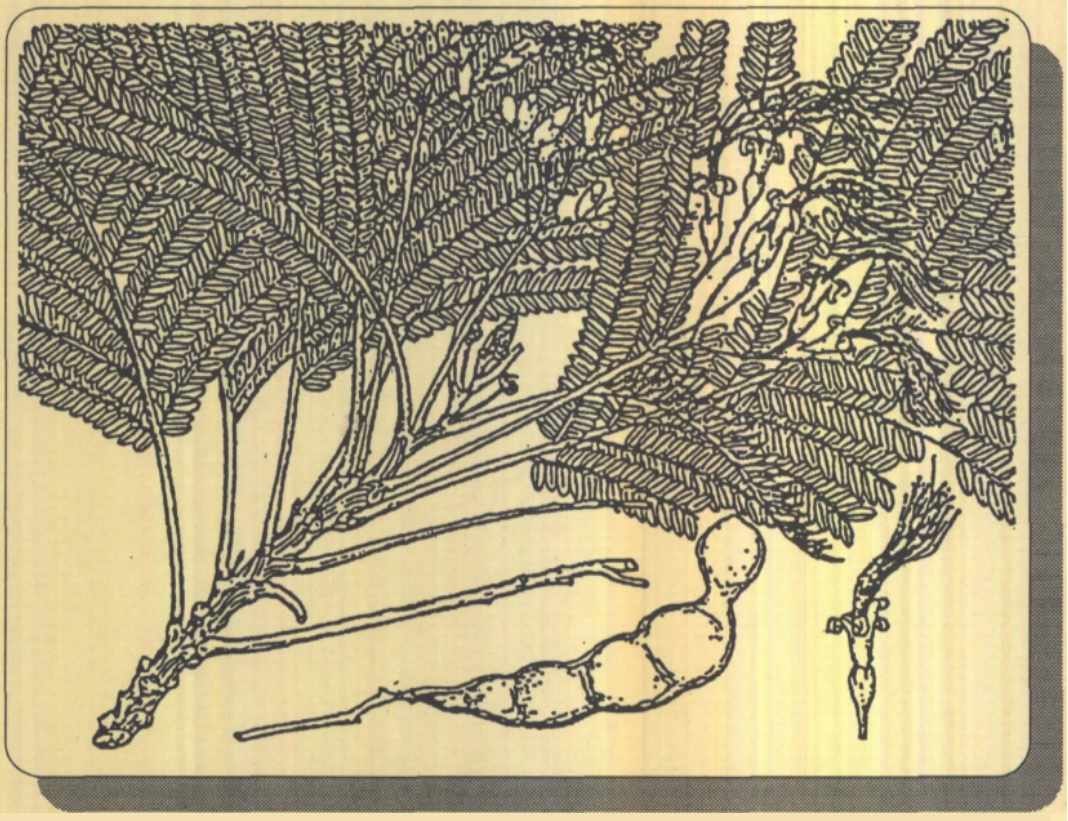
RECOVERY PLAN FOR

SERIANTHES NELSONII

FEBRUARY, 1994



U.S. Fish and Wildlife Service, Pacific Region

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RECOVERY PLAN FOR

SERIANTHES NELSONII

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: Don Weathers
Regional Director, U.S. Fish and Wildlife Service

Date: 2/2/94

THIS IS THE COMPLETED RECOVERY PLAN FOR SERIANTHES NELSONII (FABACEAE). IT DELINEATES REASONABLE ACTIONS THAT ARE BELIEVED TO BE REQUIRED TO RECOVER AND/OR PROTECT THE SPECIES. 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. THIS RECOVERY PLAN DOES NOT NECESSARILY REPRESENT OFFICIAL POSITIONS OF OR APPROVALS OF THE COOPERATING AGENCIES, AND IT DOES NOT NECESSARILY REPRESENT THE VIEWS OF ALL INDIVIDUALS WHO PLAYED A ROLE IN PREPARING THE PLAN. IT IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS, CHANGES IN SPECIES STATUS, AND COMPLETION OF TASKS DESCRIBED IN THE PLAN.

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EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR SERIANTHES NELSONII

Current Status: This species is federally listed as endangered. Two populations are known from Rota and Guam in the southern Mariana Islands. These consist of 121 mature trees on Rota and 1 mature tree on Guam.

Habitat Requirements and Limiting Factors: All remaining Serianthes nelsonii occur in native limestone forest on soils derived from limestone substrates, with most trees growing on or near steep hillsides or cliffs. The species formerly inhabited sites with volcanic soils in southern Guam. Current information suggests that a number of factors are involved in the decline of the species, with overbrowsing by introduced ungulates, especially Philippine deer, and predation on seeds and seedlings by insects thought to be the two major problems. These have resulted in nearly complete lack of regeneration for a number of years, producing a population highly skewed toward mature individuals.

Recovery Objective: Downlisting to Threatened

Recovery Criteria: The existing 122 trees and their habitat must be protected and managed. Populations on both islands must be expanded so that each contains at least two subpopulations, each with enough reproductive plants to effectively maintain the populations through the production of seeds, seedlings and mature plants.

Actions needed:

1. Secure habitat of current populations and manage threats.
2. Conduct research on limiting factors.
3. Augment existing populations.
4. Reestablish in former range.
5. Validate recovery objectives.

Total Estimated Cost of Recovery ($1,000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1993	52.25	0	61	0	0	113.25
1994	365.45	167	87.8	87	0	707.25
1995	347.25	167	73	65	0	652.25
1996	127.15	167	58	25	0	377.15
1997	127.15	167	58	25	0	377.15
1998	127.15	167	12	25	0	331.15
1999	21.75	128	6	3	0	158.75
2000	21.75	128	0	3	0	152.75
2001	21.75	128	0	3	0	152.75
2002	21.75	128	0	3	0	152.75
2003	21.75	128	0	3	0	152.75
2004	21.75	0	0	3	0	24.75
2005	21.75	0	0	3	0	24.75
2006	21.75	0	0	3	0	24.75
2007	21.75	0	0	3	0	24.75
2008	21.75	0	0	3	0	29.75
2009	21.75	0	0	3	0	30.75
Total	1385.65	1475	355.8	270	11	3497.45

Date of Recovery: Downlisting to Threatened should initiate in 2009, if recovery criteria are met.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PART I. INTRODUCTION

BRIEF OVERVIEW

Native ecosystems in the Mariana Islands have experienced considerable degradation and destruction since the arrival of the first humans. Plant communities on the five southernmost islands of Guam, Rota, Aguijan, Tinian, and Saipan have probably undergone the most severe alterations. The changes can be blamed on a variety of causes. These include forest losses due to agricultural and wartime activities; rapid modern development; the introduction of non-native animals, plants, and plant pathogens; and declines in populations or extirpations of some pollinators and seed dispersers, such as fruit bats, insects, and on Guam, nearly all of the indigenous forest birds. The resulting alterations have undoubtedly led to decreases in many plant species.

Thus far, little effort has been directed at creating an inventory of rare plants in the Marianas. A number of species probably deserve official protection; however, only one, Serianthes nelsonii (Fabaceae), is currently recognized as endangered by the U.S. Fish and Wildlife Service (Service). Serianthes nelsonii is restricted to the islands of Rota and Guam, with the bulk of the population on Rota (Figure 1). It is threatened primarily by the browsing of introduced ungulates and infestations of herbivorous insects.

Serianthes nelsonii was federally listed as endangered on February 18, 1987 (52 FR 4907-4910). The effective date of the listing was March 20, 1987. Critical habitat was not designated for the species. The tree is also listed as endangered on the Red Data List for Plants, the Commonwealth of the Northern Mariana Islands (CNMI) Endangered Species List, and the Guam Endangered Species List.

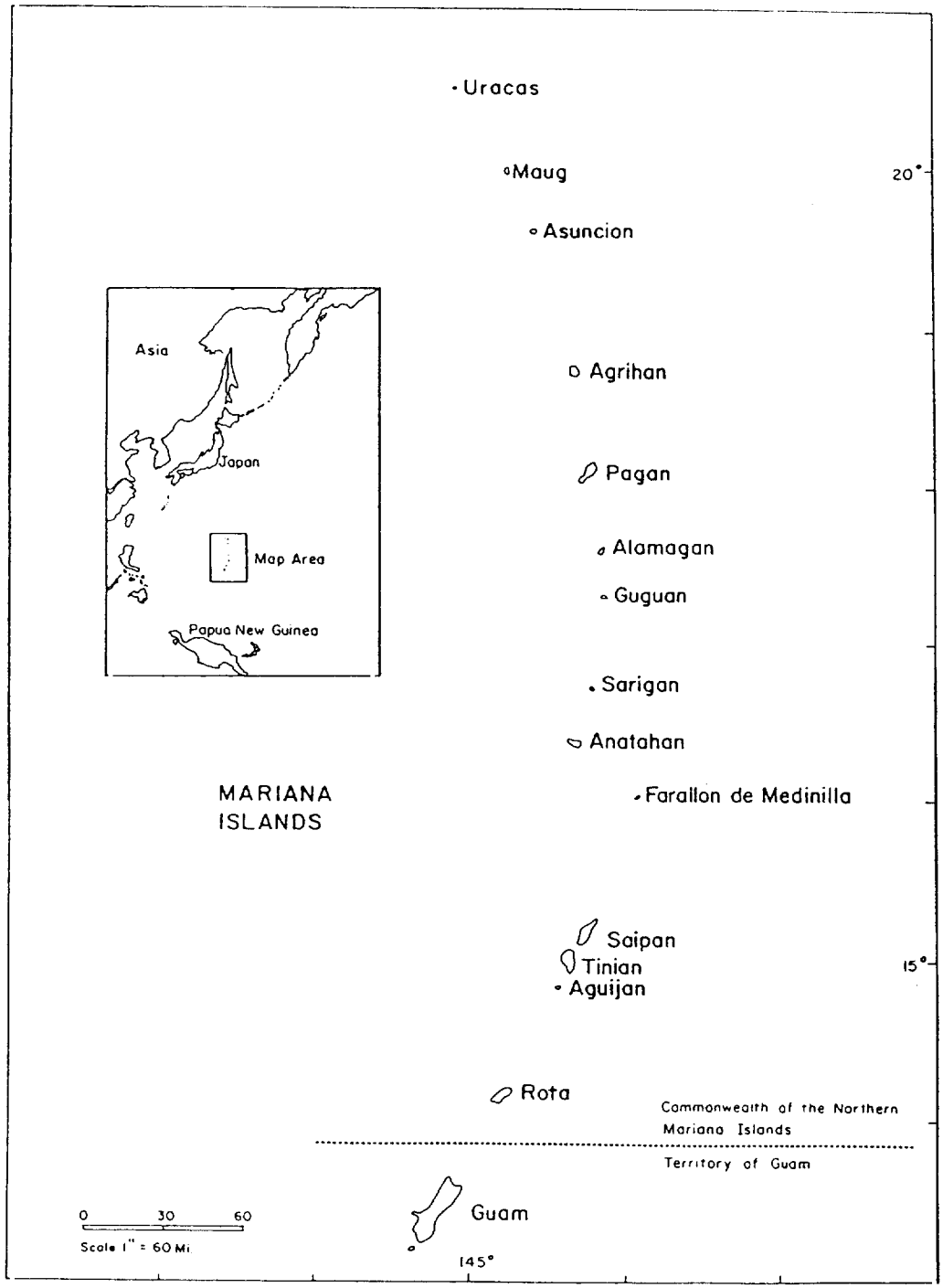

Figure 1. Map of the Mariana Islands

TAXONOMY

The genus Serianthes Bentham consists of 10 species distributed from the Malay Peninsula and Sumatra eastward to Micronesia and French Polynesia, with New Caledonia or another region of Melanesia considered the main center of diversity (Fosberg 1960). A review of the genus is provided by Fosberg (1960). Serianthes is in the family Fabaceae, and the subfamily Mimosoidae, which is considered a separate family by some botanists.

The earliest known collection of Serianthes nelsonii was made on Guam by Antoine-Alfred Marche in the late 1800s, but this material remained unstudied until after World War II (Fosberg and Sachet 1957). Specimens of Serianthes nelsonii were also collected in 1916 and 1918 by Peter Nelson and were used by Elmer D. Merrill to describe the species (Merrill 1919, Herbst 1984). The holotype designated by Merrill was destroyed in the bombing of the herbarium at the Bureau of Science, Manila, during World War II (Fosberg 1960). Isotypes with incomplete locality data were deposited at the herbaria of the Bishop Museum in Hawaii, the Arnold Arboretum at Harvard University, and the Bogor Botanical Garden in Indonesia (Herbst 1984). The species was first reported on Rota by Kanehira (1933). No synonyms have been applied to Serianthes nelsonii.

Serianthes nelsonii has two Chamorro names. The name *tronkon guafi*, which means "fire tree", is currently used on Rota (U.S. Fish and Wildlife Service 1987). On Guam, the tree is known as *hayun lagu*, which translates as "foreign wood" or "wood of the north" (Merrill 1919). Kanehira used a derivation of this name, *hayurango* in his original report for Rota. The meaning of this name caused Nelson and Kanehira to speculate that the tree was introduced to Guam and Rota (Merrill 1919, Kanehira 1933). Since Serianthes nelsonii has never been found outside of the islands of Guam and Rota, it is now considered endemic to these islands (G. Wiles, personal communciation 1993). No English names exist for Serianthes nelsonii.

A partial listing of herbaria with specimens of Serianthes nelsonii includes the following institutions: Arnold Arboretum, Bogor Botanical Garden, Bernice P. Bishop Museum, Northeast Louisiana State University, Queensland Herbarium, Royal Botanic Gardens at Kew, U.S. National Museum, University of Guam (UOG), University of the Ryukyus (Fosberg 1960; Lynn Raulerson, University Of Guam, personal communication 1991).

SPECIES DESCRIPTION

Serianthes nelsonii is one of the largest native trees in the Marianas. Merrill (1919) reported heights of 20 meters (66 feet) or more and trunk diameters of almost 2 meters (6.6 feet) for trees on Guam. During a recent survey on Rota, trees were found with heights of up to 36 meters (118 feet) and trunks of up to 1.83 meters (6 feet) in diameter (Jurgensen 1992). Mature individuals frequently have large spreading crowns, with several of the largest trees on Rota having crown diameters of 21-23 meters (69-75 feet). The species is further characterized by cylindrical boles (in all but the largest trees, which develop deep folds in the trunk) and often one or more large roots exposed on the surface of the ground. The bark is smooth and light brown in color. Nitrogen-fixing nodules occur on the roots (J.H. Lawrence, Guam Division of Forestry and Soil Resources, personal communication 1992).

Fine rusty hairs cover the flowers, seed pods, and newer vegetative growth of Serianthes nelsonii. Leaves are 18-38 centimeters (7.1-15.0 inches) long and doubly pinnate, with 10-20 pairs of pinnae and 13-30 pairs of small dark-green leaflets on each pinna (Figure 2) (Merrill 1919, Kanehira 1933, Stone 1970). The leaflets are oblong, obtuse, and about 5 millimeters (0.2 inches) long by 2 millimeters (0.1 inches) wide. Flowers are brush-like and pinkish in appearance, and have short pedicels of about 2 millimeters (0.1 inches). The calyx is narrowly cylindrical and 7-10 millimeters (0.3-0.4 inches) long. The

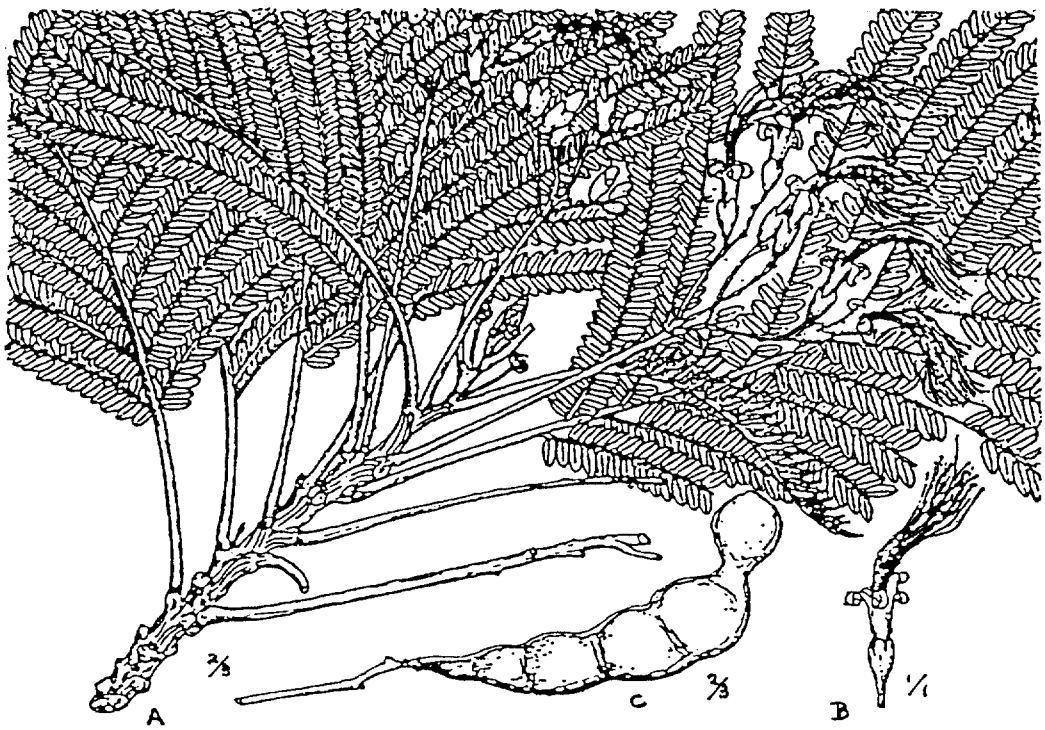

Figure 2. Branch with leaves and inflorescences (a), flower (b), and seed pod (c) of Serianthes nelsonii. Reprinted from Kanehira (1933) and Stone (1970).

corolla is cylindrical, pale greenish and white with recurved lobes, and 15-23 millimeters (0.6-0.9 inches) long. The filaments extend 1.5-2.5 centimeters (0.6-1.0 inches) beyond the petals, are white at the base, pink to maroon for most of their length, and tipped with a yellow anther. The fruit is a hard dry pod, 2-12 centimeters (0.8-4.7 inches) long and 1.5-2.5 centimeters (0.6-1.0 inches) wide, and contains one to five seeds. The seeds are hard, shiny, smooth, brown, flattened, slightly elliptic, and about 8 by 10 millimeters (0.3 by 0.4 inches) in size. Illustrations of Serianthes nelsonii appear in Kanehira (1933), Stone (1970), Moore and Krizman (1981), Herbst (1984), and Raulerson and Rinehart (1991).

Seedlings closely resemble those of tangantangan (Leucaena leucocephala; Fabaceae), a small introduced tree that is abundant in disturbed areas on Rota and Guam. The seedlings of Serianthes nelsonii can be distinguished by the fine pubescence on new leaf buds, which changes from whitish to rust-colored as the plants become older. The leaf buds of tangantangan are glabrous. A second species of Serianthes, S. kanehirae, also is native to Micronesia, with S. kanehirae var. kanehirae occurring in Palau and S. kanehirae var. yapensis found in Yap. A few of these trees have been planted on Guam and Saipan. They are distinguishable from Serianthes nelsonii by having larger leaflets and seed pods, and yellowish white flowers.

HABITAT DESCRIPTION

Members of the genus Serianthes generally occur on islands, in areas with calcareous or volcanic soils (Fosberg 1960). All surviving Serianthes nelsonii on Rota and Guam, plus those from Merrill's former Upe subpopulation, occur on limestone-derived soils. Most of the trees on Rota grow on or near steep hillsides and cliffs, but none on either island appear to be found in severe karst formations. Most surviving trees grow in mature limestone forests, with a few individuals also present in secondary forests

(see Fosberg [1960] and Stone [1970] for descriptions of plant communities). In Subpopulation 7 on Rota, Serianthes nelsonii is the dominant canopy species.

The two Serianthes nelsonii from the Tarzan River Valley in south-central Guam were the only individuals known to have grown on volcanic soils. These occurred in a small sloping patch of ravine forest surrounded by grassland dominated by Miscanthus floridulus. The Abu location noted in Merrill (1919), represents a second location where the species inhabited volcanic soils.

Trees on Rota occur at elevations ranging from 150-420 meters (490-1,380 feet), while the 6 individuals known on Guam since the 1970s were found at elevations of 120-175 meters (400-575 feet).

ECONOMIC VALUE OF THE SPECIES

Adult Serianthes nelsonii are attractive and worthy of cultivation as an ornamental (Herbst 1984) and shade tree. Because of its large size and the quality of its wood, it has potential economic value as a lumber producer. It is not known whether the species was ever harvested for its wood by Chamorros or early European settlers. Another member of the genus, Serianthes melanesica, produces commercial-quality timber (Alston 1982).

HISTORIC RANGE AND POPULATION STATUS

Serianthes nelsonii is endemic to Rota and Guam in the southern Mariana Islands. There are no historic accounts of its status and distribution on Rota, and the locations where Kanehira collected his specimens are unknown. A brief initial inventory of Serianthes nelsonii on the island was completed by Robinson (1984), who reported 64 trees in 8 subpopulations at Gayaugan and Isang (Table 1). None of the trees had estimated trunk diameters of less than 40 centimeters (15.7 inches). Despite an abundance of seed pods in the crowns of some trees, evidence of regeneration

was found in only one subpopulation. It had 40-50 small seedlings between 10 and 30 centimeters (3.9-11.9 inches) tall and 2 older seedlings, 1 of which was 60 centimeters (23.6 inches) tall, that were probably from a previous cohort.

The original distribution of Serianthes nelsonii on Guam is poorly known, but most reported trees are from locations in the northernmost portion of the island (Fosberg 1960, Herbst 1984, specimens from the UOG Herbarium). The type locality designated from Nelson's specimens was "Upe District and hills back of Abu" (Merrill 1919). Upe is the general area now occupied by the main airfield and housing complex on Andersen Air Force Base (AAFB). Abu is the area adjacent to the embayment now known as Abo Cove in inner Apra Harbor in the west-central part of the island. The hills behind this site undoubtedly refer to Mt. Tenjo and Mt. Alutom, the slopes of which are now largely covered in savanna, scrubby tangantangan, and pockets of degraded ravine forest. Serianthes nelsonii was rare on Guam at the time of its discovery. Nelson reported that it was "very scarce" and that few residents were familiar with the tree (Merrill 1919). Stone (1970) also considered the species to be rare. Only six mature trees have been recorded in the wild since the early 1970s. Three were located at Ritidian Point, one was at Pati Point, and two others occurred in a ravine near the Tarzan River in south-central Guam on land owned by the Guam Government (Cotal Conservation Area). The presence of the southern trees suggests that the species was probably once more widespread on the island. As on Rota, no successful regeneration was seen during the 1970s and 1980s. In 1983, 10-15 small seedlings were present at the location near the Tarzan River, but all of these died soon after being discovered. Single, smaller trees planted as seedlings in the late 1970s survived at UOG until 1989 and at a private home in Yona until 1990. The seedlings were gathered from under the Tarzan River Valley trees.

Table 1. Population estimates of mature Serianthes nelsonii on Rota in 1984 and 1992. The ownership of some subpopulations is uncertain; these sites are marked with a "?".

Sub-pop. No.	Location	Estimated number of trees: Robinson (1984)[a]	Estimated number of trees: Jurgensen (1992)	Ownership
1	Aplalago	-	15	Diego Mediola Jack Taitano
2	Gayaugan	2	2	CNMI
3	Gayaugan	2	4	CNMI
4	Gayaugan	-	1	CNMI
5	Gayaugan	12	14	CNMI
6	Isang	7	4	CNMI
7	Gayaugan	39	36	CNMI
8	Gayaugan	-	3	CNMI
9	Gayaugan	-	1	CNMI
10	Linansa	-	2	Ramon Castro?
11	Uyulan Hulo	-	11	CNMI
12	Hocog farm, Isang	-	14	Paterno Hocog?
13	Hocog farm, Isang	2	3	Paterno Hocog?
14	Lupok	-	8	CNMI
15	Palii	-	1	CNMI
16	Palii	-	2	CNMI
Totals		64	121	

[a]some of Robinson's (1984) subpopulations have been combined with each other to correspond with those of Jurgensen (1992).

CURRENT RANGE AND POPULATION STATUS

Maps or descriptions of the exact locations of known individuals will not be included in this Plan due to the possibility that vandalization or unauthorized collection could be encouraged by the public release of this information. The U.S. Fish and Wildlife Service will consider requests for site specific information on a case-by-case basis.

Increased floral survey work on Rota and Guam during the 1980s and early 1990s by staff of the UOG Herbarium, the CNMI Department of Natural Resources, the Guam Division of Aquatic and Wildlife Resources (GDAWR), U.S. Forest Service, and others has located only a few additional Serianthes nelsonii. The current total population estimate for both islands is 122 trees. Populations remain senescent, with little or no successful regeneration occurring. Populations on both islands are comprised almost entirely of mature trees with small to moderate numbers of young seedlings mostly less than 30 centimeters (11.8 inches) tall growing beneath some of them. Several saplings exist on Rota, but none are known to occur on Guam.

Since 1984, 57 additional trees have been discovered on Rota, bringing the total population estimate for the island to 121 trees (Table 1). Many of the new trees were found during a 2-week survey conducted by the U.S. Forest Service and CNMI Department of Natural Resources in 1992 (Jurgensen 1992). A total of 16 subpopulations are now known to exist, the largest of which contains 36 trees (Table 1). Most of the population is located on the western side of the island. At least 12 of the 16 subpopulations occur on land owned by the CNMI government. Some mortality has occurred since Robinson's (1984) survey. Only four trees now survive in Subpopulation 6 and several individuals may have died in Subpopulation 7.

On Guam, only one adult tree located near Ritidian Point is still known to survive in the wild. A second tree, which was discovered in Northwest Field in July 1991, was killed during

Typhoon Omar in August 1992. Its discovery gives hope that a few more individuals may occur in the same general area. As of September 1993, 5 seedlings, all less than 50 centimeters (19.7 inches) tall, continued to remain on the site of the storm-killed tree, and 1 seedling of 90 centimeters (35.4 inches) was beneath the surviving tree. Both sites are on AAFB, which is federally owned. A survey of the Abu site in the Mt. Tenjo-Mt. Alutom region failed to find any trees in 1992.

It is unlikely that significant numbers of additional trees remain to be discovered on either island. However, continued surveys on Rota and Guam may find a few more individual trees or small subpopulations.

LIFE HISTORY

The population of Serianthes nelsonii on Rota currently has a mean diameter at breast height (DBH) of 70.1 centimeters (27.6 inches) (n=90), with most (68.9 percent) individuals having diameters ranging from 40-100 centimeters (15.7-39.4 inches) (Figure 3), as determined by Jurgensen (1992). About 3 percent of the population have DBHs greater than 140 centimeters (55.1 inches), while the two smallest trees have diameters of 13 and 17 centimeters (5.1 and 6.7 inches). Trees at Ritidian Point and Northwest Field, Guam, had DBHs of 50 centimeters (19.7 inches) and 64 centimeters (25.2 inches), respectively, in 1992 (G. Wiles, personal observation 1992).

Other aspects of the life history of Serianthes nelsonii are poorly known. Data on the phenology of leafing, flowering, and fruiting appear in Schreiner and Nafus (1991), and are supplemented with incidental information from Merrill (1919), Herbst (1984), and Robinson (1984), as well as from labels of herbarium specimens and unpublished observations by G. Wiles. New leaves are produced continuously throughout the year, but production declines during the dry season from January to June, when most branches are dormant (Schreiner and Nafus 1991).

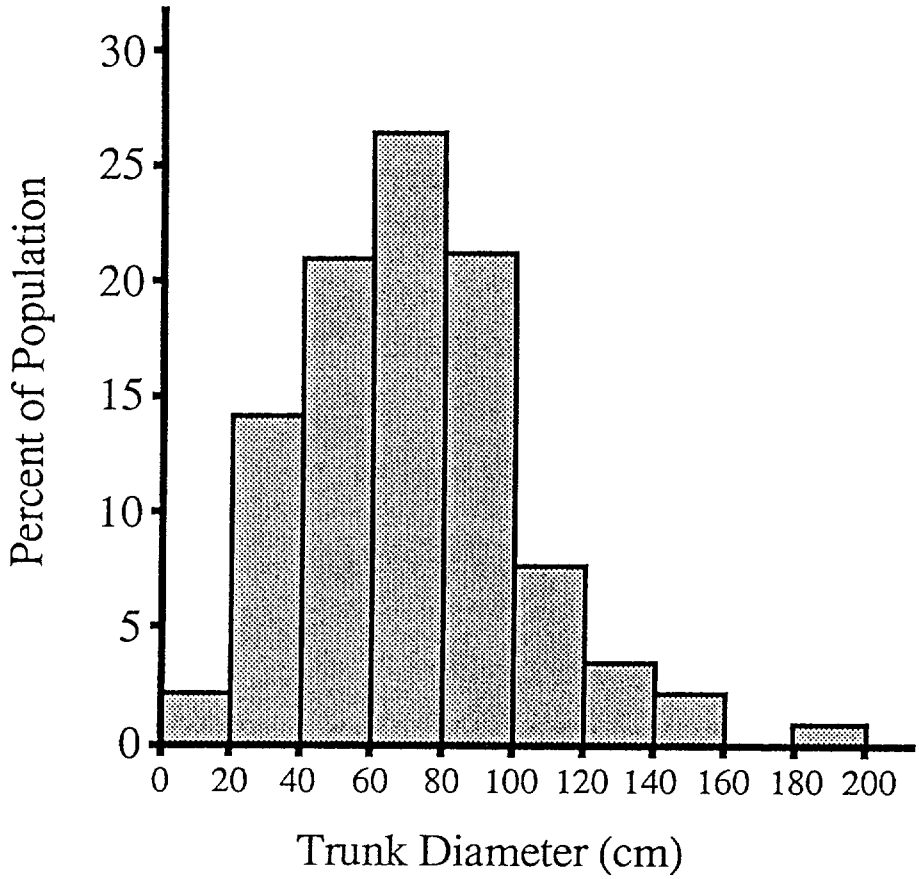

Figure 3. Distribution of trunk diameters (DBHs) of Serianthes nelsonii (n=90) on Rota, Mariana Islands, in 1992. Adapted from data presented in Jurgensen (1992).

Flowers and flower buds have been seen in all months, but Schreiner and Nafus (1991) recorded the highest proportion of branches with flowers in May and June. Mature seed pods have also been recorded in all months. Seed crops can be large, with 500-1,000 pods seen in the crown of one large tree on Rota (G. Wiles, personal observation, 1992). The age and size at which reproduction begins in the wild is unknown, but flowers and pods were produced by an approximately 10-year-old cultivated tree with a DBH of 19 centimeters (7.5 inches).

Methods of pollination and seed dispersal are unreported for Serianthes nelsonii and the remainder of the genus. On Rota, Marianas fruit bats (Pteropus mariannus) occasionally feed at the flowers of Serianthes nelsonii (Estanislao M. Taisacan, CNMI Division of Fish and Wildlife, personal communication 1990) and may assist in pollination. Seedlings found on Rota and Guam in recent years have all been located under the crowns of parent trees. This suggests that seed dispersal is poor under natural conditions or has been greatly reduced for undetermined reasons. The current distributional patterns of Serianthes nelsonii on Rota, where trees are frequently found in groups or pairs, further indicate that little seed dispersal has occurred there for many years and that most regeneration has happened next to existing trees.

On both islands, Serianthes nelsonii supports a diverse community of arthropods, including a number of predators, such as several species of spiders, preying mantids, ants, and beetles, (some native and some introduced), (Schreiner and Nafus 1991). Arthropod predators are abundant for much of the year and help control outbreaks of other insects. Maintenance of predator populations is probably critical to the health of the trees.

A variety of epiphytic ferns (Asplenium laserpitifolium, A. nidus, A. pellucidum, Davallia solida, Nephrolepis acutifolia, Polypodium punctatum, Phymatosorus scolopendria, Pyrrosia lanceolata, Vittaria incurvata), orchids (Bulbophyllum sp.,

Dendrobium guamense, Taeniophyllum mariannense), and other plants (Dischidia puberula, Ficus sp., Freycinetia reineckei, and Peperomia mariannensis) grow in the crowns of Serianthes nelsonii (G. Wiles, personal observation).

REASONS FOR DECLINE AND CURRENT THREATS

A number of factors are involved in the decline of Serianthes nelsonii. However, these causes are poorly studied, aside from recent work on insect herbivores by Schreiner and Nafus (1991). Based on initial investigations and field observations, the primary threat to Serianthes nelsonii on both islands is a lack of regeneration probably caused by the browsing of seedlings by deer and by predation on seeds by insects. On Guam, herbivory by both native and introduced mealybugs and other insects has been another important problem for most trees for at least a decade. Insect herbivory appears to be less of a concern on Rota, where most trees exhibit healthy foliage.

(1) Herbivory by Introduced Ungulates

The native flora of the Mariana Islands evolved in an environment free of ungulates, which makes many species susceptible to heavy browsing. Forests on Guam, Rota, and other islands exhibit distinctive signs of overbrowsing, and regeneration of many plant species appears to be greatly reduced or eliminated in some areas. Three species of ungulates, Philippine deer (Cervus mariannus), feral pigs (Sus scrofa), and domestic cattle (Bos taurus), are probably involved in the destruction of young Serianthes nelsonii.

Deer were introduced to Guam by the Spanish between 1771 and 1774 (Safford 1905) and were established on Rota by at least the 1880s (Marche 1889). Currently, they are common in all areas with Serianthes nelsonii on both islands, as evidenced by browsing sign, the presence of pellet groups and game trails, and sightings of animals. Feral pigs on Guam, which are most likely descendants

from domestic stock brought to the island in the 1600s (Intoh 1986), are abundant on AAFB and in many other forested areas. Pigs and pig sign (i.e., rooting and rubbing on trees) were observed close to both trees on the airbase in 1991. The historic occurrence of feral pigs on Rota is poorly known, but they apparently were present in the 1880s (Marche 1889) and then died out. A small population became reestablished along the northern coast from Sakaya to Tatgua in the 1980s (Clifford G. Rice, CNMI Division of Fish and Wildlife, personal communication 1991), and occurs within 1 kilometer (0.6 miles) of the nearest known Serianthes nelsonii. Small numbers of cattle are sometimes allowed to graze in forests near farms on Rota. A few cattle droppings have been observed in the grove of Serianthes nelsonii comprising Subpopulation 1 (L. Jurgensen, U.S. Forest Service, personal communication 1992).

Deer consume the seedlings of Serianthes nelsonii (Lucas and Synge 1978). It is likely that feral pigs and domestic cattle also feed on the young shoots of the species or may destroy them through rooting or trampling. Deer are probably the major cause of seedling mortality on Rota because of their much greater numbers, but on Guam, seedling losses may be equally attributable to feral pigs. The only data on this problem exist for Guam, where seedlings were removed by animals under both remaining trees in 1991 (Schreiner and Nafus 1991, Celestino F. Aguon, GDAWR, personal communication 1991). At the tree in Northwest Field, 5 of 37 seedlings had their stems nipped off at ground level before protective screening could be installed.

(2) Insect Infestations

A variety of insects, many of which are introductions with broad host species ranges, feed on wild and captive Serianthes nelsonii (Table 2) (Schreiner and Nafus 1991). The diversity of insect herbivores and seed predators appears to be greater on Rota than Guam, but this is probably because of the larger number of trees examined on Rota. Large variations in the composition of

Table 2. Arthropod fauna known or suspected to feed on *Serianthes nelsonii* (Schreiner and Nafus 1991). Identifications are pending for many of the species.

	Presence on mature trees		Presence on potted seedlings on Guam
	Rota	Guam	
Number of trees inspected	12	3	20
Acari			
Unidentified mite	x	x	
Hemiptera			
Aphis craccivora			x
Lallemandana phalerata	x		
Leptocentrus taurus	x		
Kallitaxila crini[a]		x	
Steatococcus samaraius[a]	x	x	x
Ferrisia virgata	x	x	
Planococcus citri[a]		x	
Dysmiococcus neobrevipes[a]		x	
Dysmiococcus brevipes[a]			x
Coleoptera			
Myocallis guamensis	x		
Myocallis spinifer	x		
Curculionidae sp.	x		
Alleculidae sp. (?)	x		
Elateridae sp.	x		
Rhyparida sp.[a]		x[b]	x
Lepidoptera			
Eurema blanda	x	x	
Geometridae sp. 1	x		x
Geometridae sp. 2	x		
Geometridae sp. 3			x
Geomeeetridae sp. 4			x
Noctuidae sp.	x		
Micro-Lepidoptera sp.		x	
Isoptera			
Termitidae sp.		x[c]	

[a]Species known to be introduced to the Mariana Islands.
[b]Two beetles were found in a curled leaf, but were not observed feeding.
[c]Probably feeds only on dead wood.

insect communities were noted among individual trees, with some species, such as weevils (Curculionidae), common on some trees and absent from others (Schreiner and Nafus 1991). Introduced species comprise a larger percentage of the insect fauna on Serianthes nelsonii on Guam than Rota. It is possible that some of the native species of insects that once fed on Serianthes nelsonii on Guam were lost because of the small number of surviving trees.

Initial studies indicate that mealybugs and the butterfly Eurema blanda are the insects most damaging to Serianthes nelsonii. Four species of mealybugs (Dysmicoccus brevipes, D. neobrevipes, Planococcus citri, and Ferrisia virgata) are known to feed on the leaves, leaf buds, branch tips, and roots of trees and seedlings (Schreiner and Nafus 1991). This type of herbivory often results in twisted, stunted branches and growing tips, and causes excessive pruning of branches. Chronic infestations weaken the trees, predisposing them to death if other stresses are added. Ferrisia virgata can distort immature seed pods, and thus may impact seed production. Dysmicoccus brevipes, D. neobrevipes, and Planococcus citri have been introduced to the Marianas, and it is suspected that Serianthes nelsonii has no genetic adaptations allowing it to tolerate even limited feeding by these insects. Initial surveys indicate that Serianthes nelsonii suffers considerably more from mealybug infestations on Guam, with visible damage to foliage being less detectable on Rota (Schreiner and Nafus 1991, G. Wiles, personal observation). Problems with mealybugs appear to be more severe in urban and suburban settings than in forested areas. Observations also reveal that predatory insects are important in limiting mealybug outbreaks (Schreiner and Nafus 1991).

In the Marianas, mealybugs live in close association with, or are "tended" by, several species of ants (Technomyrmex albipes, Anoplolepis longipes, and Pheidole megacephala; Formicidae). The ants, (some native and some introduced) are able to transport the mealybugs to new plants or to new locations on the same plants.

They also protect the mealybugs from parasitoids and predators, and in turn collect honeydew from the mealybugs. Honeydew is a sugary liquid exuded by the mealybugs. Control of the ants often results in reduced mealybug populations.

In 1990 and 1991, Dysmicoccus brevipes invaded most of the 20 potted Serianthes nelsonii seedlings kept at UOG (Schreiner and Nafus 1991). The insects occurred primarily below the soil line on the bases of stems, but also infested the leaves, causing distortion of the growing tips and leaves similar to that observed in wild trees. The infestations killed at least 10 of the plants despite attempts at control with insecticide drenches. The seedlings were drenched with malathion (50 percent emulsifiable concentrate) at the rate of about 7.5 milliliters/liter (2 tablespoons/gallon) of water. This treatment effectively killed the mealybugs, but also killed young plants with stems not yet fully lignified. Older seedlings were less affected. As the seedlings grew, control with insecticides became more difficult because the insects were able to shelter themselves beneath the lateral roots. Seedlings more than a year old continued to be highly susceptible to mealybug infestations on the roots and were easily killed by them. It is unknown how large Serianthes nelsonii must grow before it can withstand root damage caused by mealybugs. In the wild, seedlings under the heavy shade of the forest canopy grow much slower than cultivated individuals in full sunlight. Thus, wild seedlings may remain vulnerable to mealybugs for longer periods of time.

Two other treatments proved effective at controlling mealybugs on the UOG seedlings. Dimethoate drenches killed mealybugs (and unfortunately some seedlings), while the addition of Diazinon granules to pots controlled big-headed ants (Pheidole megacephala) for brief periods of time.

The grass yellow butterfly (Eurema blanda) is capable of laying large numbers of eggs on leguminous trees, including Serianthes nelsonii. Outbreaks of caterpillars can cause severe defoliation in Serianthes nelsonii, with up to 25 percent of the

leaves removed from some trees (Schreiner and Nafus 1991). Defoliated sections may show extensive twig death, resulting in a severe pruning effect over time. Outbreaks of Eurema blanda appear to be most severe in trees with few insect predators (Schreiner and Nafus 1991). A small Serianthes nelsonii on the UOG campus died in 1989, possibly as a result of being regularly stripped by Eurema blanda. The tree died after being sprayed several times for mealybugs. The spraying may have allowed a more severe outbreak of Eurema blanda to occur by eliminating predatory insects. Caterpillars of other lepidopterans (Geometridae and Noctuidae) were abundant on Serianthes nelsonii on Rota (Schreiner and Nafus 1991) and may also be important herbivores. The identifications of the species have not yet been made.

Insect predation on seed pods appears to be another significant factor reducing reproductive output in Serianthes nelsonii on Rota, but has not been noted on Guam. Robinson (1984) found unidentified insect larvae in immature pods on a tree and reported that all of the mature pods had suffered insect predation. Schreiner and Nafus (1991) found a species of weevil (possibly a species of Allecuidae) and evidence of moth larvae boring into the pods of Serianthes nelsonii on Rota. The weevil is still unidentified, but appears similar to a species that preys on the pods of tangantangan (Leucaena leucocephala). G. Wiles (personal observation) also observed many infested pods in 1992.

Serianthes nelsonii is vulnerable to other insects as well. Several seedlings at the Waimea Arboretum and Botanical Garden in Oahu, Hawaii, were killed by black twig borers (Xylosandrus compactus, Scolytidae, Coleoptera) (Keith R. Woolliams, Waimea Arboretum and Botanical Garden, personal communication 1991). This species is not known to be present in the Marianas. Unidentified termites (Termitidae) have invaded at least three living trees on Guam in recent years, and may have contributed to their deaths. Termite damage can weaken tree trunks and major limbs, making them more susceptible to breakage during typhoons, as occurred to the tree in Northwest Field.

(3) Typhoon Damage

Typhoons are common in the Mariana Islands. Severe storms tend to strike islands in the archipelago on the average of about once every 10-20 years. Typhoons represent little threat to plant and animal species that are common and well-distributed on an island. However, the loss of a few individuals to storms can be a serious problem to endangered populations.

Some Serianthes nelsonii have been killed or had major limbs broken during typhoons. Insect damage may have contributed to the susceptibility of these trees. Losses have included a tree in Subpopulation 6 on Rota killed by Typhoon Roy in 1988 and the tree in Northwest Field, Guam, killed by Typhoon Omar in 1992. The trunk of the latter tree was snapped about 3 meters (9.8 feet) off the ground where a termite colony had hollowed out the interior. In 1990, a small tree in Yona, Guam, died soon after being completely defoliated by Typhoon Russ after it had been continually weakened by mealybug herbivory.

Several large trees on Rota exhibit major broken limbs or have been completely toppled, presumably by typhoons, but continue to survive. The tree on Pati Point, Guam, lost half its crown when a main branch broke off in Typhoon Pamela in 1976. This tree was invaded by termites, apparently through the wound of the lost limb, and eventually died about 1985. Many larger trees on Rota exhibit narrow cracks or fissures in the bark of their lower trunks (L. Jurgensen, personal communication 1992). Healed scars are also common. These may be stress fractures caused by strong winds.

(4) Habitat Loss

Destruction of native forest probably played a role in the historic decline of Serianthes nelsonii, although this is largely speculative. Fairly large areas of both islands still retain primary forest, yet have no Serianthes nelsonii. On Rota, some trees may have been cut during the Japanese occupation in the 1930s, when up to 75 percent of the island was used for sugar cane

production, phosphate mining, and other activities (Bowers 1950).

On Guam, the construction of AAFB during and immediately after World War II almost certainly destroyed some trees (perhaps including Merrill's Upe subpopulation) when large areas were cleared to make room for runways and support facilities. The land around the tree in Northwest Field appears to have been bulldozed many years ago, probably when the adjoining airfield was under construction. The only known recent incident of tree loss occurred in the early 1970s, when the Air Force inadvertently bulldozed a mature tree growing next to a small road on Ritidian Point. A Navy proposal to build a radar system in 1988 might have resulted in the destruction of the Northwest Field tree had the project not been canceled.

(5) Inbreeding

Depauperate populations on both islands and the isolation of some trees, particularly on Guam, suggests that both populations are at risk of losing genetic diversity because of restricted opportunities for outbreeding. Lowered levels of cross-pollination and increased self-fertilization can reduce reproductive output through lessened seed production, embryo viability, and seedling vigor.

(6) Wildland Fires

Large areas of grassland burn annually in southern Guam. Wildfires often burn into the edges of neighboring ravine forests, killing a few trees in the process. A fire of this type killed one of the Serianthes nelsonii in the Tarzan River Valley in the late 1970s and severely injured the second tree, which died in about 1982 (Carlos L.T. Noquez, Guam Division of Forestry and Soil Resources, personal communication 1991).

(7) Problems with Other Animals and Plants

Robinson (1984) observed large numbers of broken branch tips with seed pods and new growth on the ground below a group of

Serianthes nelsonii on Rota. He speculated that the damage was caused by wind or black drongos (Dicrurus macrocercus), an introduced bird that has been reported to commonly strip the branches from other tree species. Nafus observed similar damage under a tree on Rota in 1991, but was told that fruit bats had clipped the twigs (Isaac M. Calvo, CNMI Department of Natural Resources, Rota, personal communication 1990). Only a few broken twig tips of this type were noted during the population census in 1992 (L. Jurgensen, personal communication 1992). This problem has not been recorded on Guam.

A few of the Serianthes nelsonii on Rota and three of the last four surviving individuals in northern Guam had small strangling figs (Ficus prolixa or F. saffordii) growing on them. None of the trees was severely damaged by the figs, but death may have eventually resulted had the figs not been removed.

CONSERVATION EFFORTS

(1) Federal actions. The Service listed Serianthes nelsonii as endangered in 1987 (52 FR 4907-4910), and is currently evaluating two separate proposals, one to create a National Wildlife Refuge and the other to declare Critical Habitat for six species of forest birds and fruit bats, in areas of northern Guam that contain the surviving Serianthes nelsonii. Final decisions on both proposals should be made in 1993. The U.S. Forest Service directed a survey of the species on Rota in 1992. The U.S. Air Force and Navy have been cooperative in allowing inventories and initial research to be performed on their properties on Guam, and the Anderson Air Force Base 633 Civil Engineering squadron recently constructed a 60 acre exclosure on the base for conservation of native species, including Serianthes. A cooperative agreement addressing management of this exclosure has been developed and is currently awaiting the outcome of the Guam National Wildlife Refuge and Critical Habitat decisions.

(2) Commonwealth of the Northern Mariana Islands actions. The Rota population of Serianthes nelsonii was included in the endangered species list for the Trust Territory of the Pacific Islands (Territorial Register, Vol. 1, No. 12-29 October 1976). This list has since been deactivated. However, the tree was placed on the recently promulgated CNMI Endangered Species List in 1991. Personnel from the Forestry Section of the Department of Natural Resources assisted with census work in 1992. They have also collected seeds and seedlings for cultivation in nurseries on Rota and Saipan. However, all of the seedlings grown on Saipan have apparently died (Renee Thakali, CNMI Forestry Section, Saipan, personal communication 1990).

(3) Territory of Guam actions. Serianthes nelsonii was placed on the Guam Endangered Species List on 24 September 1981, and is thereby protected by the Endangered Species Act of Guam (P.L. 15-36). Staff from the Division of Aquatic and Wildlife Resources have searched for additional trees and placed cages around 35 seedlings on Anderson Air Force Base in an experiment on the causes of mortality. In addition, a 60 acre exclosure was constructed in a Northwest Field area suitable for future outplanting of Serianthes nelsonii (C. Aguon, personal communication 1993). The Division of Forestry and Soil Resources has collected some pods from surviving trees and attempted to raise a few seedlings.

(4) University of Guam and Non-Governmental Organization actions. Entomologists from the College of Agriculture and Life Sciences at UOG are conducting ongoing studies on insect communities and herbivory on Serianthes nelsonii. They have also raised a few seedlings while doing their research. Staff from the UOG Herbarium have gathered and maintained scientific specimens of Serianthes nelsonii and performed plant inventories on both islands. In 1989 and 1990, the Marianas Audubon Society collected seed pods for propagation work at UOG and pruned dead branches and

termite-damaged limbs from the tree at Ritidian Point. They also attempted to control insect pests by spraying Malathion and applying Tanglefoot to a cultivated tree on the UOG campus.

Cultivation

Cultivation of small numbers of Serianthes nelsonii seedlings has been attempted by the CNMI Department of Natural Resources (number of seedlings unknown), Guam Division of Forestry and Soil Resources (about 20 seedlings), the UOG College of Agriculture and Life Sciences (20 seedlings), and the Waimea Arboretum and Botanical Garden (3 seedlings). Success was generally poor, with most seedlings succumbing within a few months to one or two years. The primary cause of mortality was herbivory by mealybugs on Guam (Schreiner and Nafus 1991, C.L.T. Noquez, personal communication 1991) and black twig borers in Hawaii (K.R. Woolliams, personal communication 1991).

The hard seed coats of Serianthes nelsonii seeds result in reduced or slowed rates of germination. However, special treatment of seeds can improve sprouting rates. In 1989, the Guam Division of Forestry and Soil Resources tested three types of treatments (boiling, cracking with pliers, and acid immersion) against a control of no treatment, with each having a sample size of 10 seeds. Boiling had the best results, with three seedlings produced. Acid immersion resulted in one seedling, while cracking and no treatment produced no seedlings. The boiling treatment consisted of boiling water in a pot, allowing it to cool for several seconds, and then placing the seeds in it for 45-55 minutes. The seeds were removed and then soaked for another 20-24 hours in water at room temperature. Sowing occurred on the following day. The Waimea Arboretum and Botanical Garden has reported a 30-60 percent germination rate with boiled seeds (K.R. Woolliams, personal communication 1991). Another method used by the UOG College of Agriculture and Life Sciences involved wetting the seeds for 1-2 months, drying them completely for 1-2 weeks, and wetting them again. They were then placed in pots with well

drained soil. This resulted in the eventual sprouting of nearly all the seeds. In Yap, germination of Serianthes kanehirae var. yapensis was improved by filing a notch in the seed coat (Marjorie V.C. Falanruw, U.S. Forest Service, personal communication 1990).

There is some evidence that Serianthes nelsonii seeds have a delayed germination mechanism that results in seed crops continuing to germinate over extended periods. Seeds left in pots at UOG continued to sprout for up to one year after sowing. Thus, nurseries should not quickly dispose of seeds that have failed to germinate.

PART II. RECOVERY

OBJECTIVES

Consideration for down-listing Serianthes nelsonii to threatened status should begin after browsing by ungulates and insect infestations are controlled or stopped on Rota and Guam, and the species has increased to a total of at least two populations on each island. Each population should contain at least 500 reproductive individuals in order to capture and retain the majority of the genetic variability of the population, and to help ensure that each individual population is not eliminated by small scale catastrophic events.

The target for delisting Serianthes nelsonii is to establish at least four populations on each island, each with a 10-year average of 500 or more reproductive plants. A total of at least four populations per island provides for increased long-term genetic viability and increased protection against extinction due to catastrophic events. The populations should have age structures comprised of a large proportion of adult trees and a healthy number of seedlings and immature trees. The actual breakdown of the percentages of each age class will be determined later. In order to provide some protection for the species against localized catastrophic events, populations on Rota should be separated by at least 1 kilometer (.621 miles), and at least one of the four Guam populations should be located in southern Guam.

Further study is required before the relationship between the 16 small subpopulations on Rota, and the populations required for downlisting and/or delisting can be determined. Some of these subpopulations could be augmented to reach the target size and/or several of the subpopulations could be linked to form the required populations.

NARRATIVE

1. Secure and manage sites known to have Serianthes nelsonii.

Areas with Serianthes nelsonii need permanent protection. These lands, which should include, at a minimum, areas sufficient for reproduction and augmentation (task # 3), need to be under the ownership or management of a conservation agency.

11. Secure and manage Serianthes nelsonii population on Rota.

The population is comprised of 121 trees in 16 subpopulations. Sizes of subpopulations range from 1 to 36 trees. Securing these sites can be accomplished by several methods, such as a cooperative agreement with the landowner, a lease, or purchase of the land. These arrangements will protect the trees and allow for entry into sites by managers and researchers.

111. Confirm ownership of subpopulations 10, 12 & 13 and pursue cooperative agreement.

Ownership of subpopulations 10, 12 & 13 must be confirmed. If they are owned by the CNMI, they should be included in the cooperative agreement for other CNMI owned populations. If their ownership is indeed private, a cooperative agreement, conservation easement, lease or purchase should be pursued.

112. Cooperative agreement(s) with CNMI.

Most Serianthes nelsonii (subpopulations 2-9, 11 and 14-16) on Rota occur on lands owned by the CNMI government and it is vital that these lands are not inadvertently leased out for development or agricultural uses. A cooperative agreement with CNMI should be pursued and the government should consider establishing one or more endangered plant preserves to protect the species.

113. Pursue cooperative agreement with owners of subpopulation 1 lands.

A cooperative agreement for the management of subpopulation #1 must be worked out with landowners Diego Mediola and Jack Taitano.

114. Fence to control access of introduced ungulates.

It is essential that remaining Serianthes nelsonii be

fenced to protect against grazing by introduced ungulates as soon as possible. Caging of individual seedlings under parent trees also appears to be effective, but should be done only as a temporary measure until complete fencing is done.

1141. Determine areas to be fenced.

Sizes of fenced areas should be determined on a case by case basis, and inclusion of several subpopulations within one large exclosure should be considered, particularly if they could be linked to form one of the two larger populations needed for downlisting. Loyal Mehrhoff (USFWS, personal communication 1993) suggests that populations 2,3,5 & 7 could be fenced together, protecting 56 individuals in one exclosure. At a minimum, areas should be large enough to include areas for augmentation (task # 3). Selection and clearing of fence lines should take into account factors such as local topography and distance from roads. Fencing should be at least 8 feet high in order to exclude deer, and should also exclude pigs.

1142. Fence subpopulations on CNMI land.

Implement fencing of subpopulations owned by CNMI.

1143. Fence subpopulations owned by Diego Mediola and Jack Taitano.

Implement fencing of subpopulation #1.

1144. Fence subpopulations owned by others.

Implement fencing of subpopulations 10, 12 & 13 after ownership is determined.

1145. Establish a maintenance program for upkeep of fencing and caging.

It will be necessary to do periodic maintenance of fences and cages for subpopulations 1-16 after they are constructed, including removal of weedy vines and fallen branches.

115. Prevent new clearing of forest next to Serianthes nelsonii.

Steps should be taken to prevent the cutting of trees

or large-scale clearing of forest next to existing Serianthes nelsonii. Maintenance of an intact forest canopy next to Serianthes nelsonii will reduce the potential for high winds during typhoons to break tree limbs or trunks.

116. Control insect pests.

Implementation of standardized control procedures should begin immediately after research on insect control determines appropriate methodology (see task # 32). Possible control techniques include the introduction of parasitoids for biocontrol, use of pesticides and toxic baits to control mealybugs and the ants attending them, and pruning of dead limbs and removal of epiphytes to reduce nesting habitat for ants. Consideration should be given to treating trees damaged by typhoons to lower the chances for termite invasion.

117. Remove strangler figs.

Removal of strangler figs (Ficus prolixa, F. saffordii, and F. tinctoria) may increase the life span of certain Serianthes nelsonii. Care should be taken not to damage the bark of the trees in the process.

118. Cross-fertilize flowers.

Cross-fertilization of wild Serianthes nelsonii should be done to enhance outbreeding if warranted by the results of task # 33. This may improve the vigor of subsequent generations, improve productivity, and increase resistance to insect pests and plant diseases.

119. Consider application of fertilizers to trees.

Supplemental fertilization of wild Serianthes nelsonii should be considered if warranted by the outcome of task # 25. This may improve the vigor of trees and increase their resistance to insect pests and diseases.

1110. Determine appropriate methods for limiting wildfires near Serianthes nelsonii.

Several subpopulations are located next to or near grassy fields that may occasionally catch fire. The threat of fires at these sites should be evaluated.

1111. Tag and monitor all individuals.

Long-term tagging and monitoring will be necessary to keep track of recovery and should expand to include new individuals and areas as they are established.

1112. Develop additional habitat management prescriptions, as needed.

Existing management strategies should be reviewed and altered as new information on the species becomes available.

12. Secure and manage Serianthes nelsonii population on Guam.

The habitat of the remaining adult tree and one seedling near Ritidian Point, and 5 seedlings under the recently killed tree in Northwest Field should be secured.

121. Pursue cooperative agreement with Anderson Air Force Base.

All surviving Serianthes nelsonii on Guam occur on Andersen Air Force Base. A cooperative agreement between USFWS, US Air Force, GDAWR and the Univ. of Guam for management of the 60 acre exclosure has already been developed and is awaiting the outcome of the Guam National Wildlife Refuge and Critical Habitat decisions.

122. Consider cooperative agreement with owners of former habitat.

Because seedlings of Serianthes nelsonii were present at the Tarzan River Valley site (part of the Guam governments' Cotal Conservation Reserve) as late as 1983, a cooperative agreement securing this area as a site for possible reintroduction should be considered.

123. Fence to control access of introduced ungulates.

See narrative under task # 114.

1231. Fence trees on AAFB.

The mature individual and it's seedlings as well as the seedlings growing under the recently killed mature individual must be fenced.

1232. Establish a maintenance program for upkeep of fencing and caging.

See narrative under task # 1145.

124. Prevent clearing of forest next to Serianthes nelsonii.

In the mid-1980s, the Guam Division of Forestry and Soil Resources cleared all trees in a 5-8 meter (16-26 feet) radius around the tree at Ritidian Point in an attempt to stimulate seedling growth. This type of clearing should not be repeated in the future. Maintenance of an intact forest canopy next to Serianthes nelsonii will reduce the potential for high winds during typhoons to break tree limbs or trunks.

125. Control insect pests.

See narrative under task # 116.

126. Remove strangler figs.

See narrative under task # 117.

127. Cross-fertilize flowers.

See narrative under task # 118.

128. Consider application of fertilizers to trees.

See narrative under task # 119.

129. Determine appropriate methods for limiting wildfires near Serianthes nelsonii.

Both current sites with Serianthes nelsonii on Guam are safe from wildfires because of their locations in limestone forest, which is not prone to burning. However, if new trees are discovered or new populations established, particularly in southern Guam, the likelihood of this threat should be evaluated and remedied, if necessary.

1210. Tag and monitor all individuals.

See narrative under task # 1111.

1211. Develop additional habitat management prescriptions, as needed.

See narrative under task # 1112.

13. Search for additional subpopulations.

It is unlikely that significant numbers of trees remain to be discovered on either island. However, it is important that all surviving Serianthes nelsonii be located to improve the chances of saving the species. If additional trees are found, the recovery plan will have to be updated to include them.

131. Continue surveys on Rota.

Jurgensen (1992) adequately surveyed all known subpopulations on the island, however, searches for additional trees should be continued since additional subpopulations may be discovered which could be more easily expanded to the size required for downlisting. Areas of highest priority include Lempanai, Uyulan Hulo, and other hillsides surrounding the Sabana, and the forested plateaus at Isang and on top of the Sabana. These surveys should include interviews with local residents familiar with the species and who have knowledge of these areas.

132. Search for additional subpopulations on Guam.

It is possible that additional Serianthes nelsonii exist on Guam, especially between Ritidian Point and Mergagan Point. Systematic searches for new subpopulations should be planned and executed.

133. Include newly discovered populations in management actions.

It will be necessary to include any new subpopulations that are found in the management activities outlined above.

14. Create a public education and involvement program.

A public education and involvement program would encourage the local communities to take pride and responsibility for their native trees, including Serianthes nelsonii, and would also help with maintaining fences and other recovery tasks. Such a program should be developed.

2. Conduct research important to management of Serianthes nelsonii.

Satisfactory methods are needed for controlling the limiting factors of Serianthes nelsonii. This will require some investigation and research. Efforts are needed to support management needs.

21. Investigate the ecology of Serianthes nelsonii.

Better information is needed on flowering and fruiting phenology, periods of peak germination in the wild, growth rates, pollination, seed dispersal, microbial associations with roots, and other aspects of the species' ecology. These data will help managers in the propagation of captive plants and the reestablishment of new subpopulations in the wild.

22. Investigate insect pests of Serianthes nelsonii.

Insect predation on seeds and leaves is a major threat to the survival of Serianthes nelsonii seedlings, and can weaken mature trees. The nature of these threats, and methods for controlling them should be researched.

221. Study the abundance and ecology of insect pests.

Seasonal population trends of seed predators and mealybugs, the role of ants in maintaining mealybug populations, and the natural enemies of these insects should be investigated.

222. Investigate the occurrence of seed predation by insects.

The problem of insect predation on seeds in unopened pods of Serianthes nelsonii needs further study. Research should be conducted to determine the insect species involved, their seasonality, and the severity of the problem.

223. Determine appropriate methods to control seed predation by insects.

After the species of insects are identified, plans for their control can be better formulated.

224. Investigate control of mealybugs through the introduction of suitable parasitoids.

A biocontrol program should be started to find the appropriate parasitoids of mealybugs and screen them for suitability of use. Parasitoids that will attack the mealybugs underground are particularly needed. This program will further benefit the public because mealybugs are pests of ornamentals and agricultural crops. The age at which seedlings are no longer susceptible to mealybug herbivory should also be determined.

225. Determine appropriate methods of controlling ants that attend mealybugs.

Ants may be controlled by direct pesticide application, use of selective toxic baits, and removal of nesting sites (e.g. dead limbs and root masses of epiphytes). Toxic baits may be preferable because they will have less impact on other arthropods. Research to determine the most effective baits and toxicants is needed.

23. Determine whether Serianthes nelsonii suffers reproductive suppression from inbreeding.

Genetic studies should be initiated to investigate the extent of the threat of inbreeding in the species. Research is needed to determine whether the plant is self-fertile or an obligate outcrosser. Experiments with cross-fertilization should be conducted to determine the benefits of this type of program to future conservation efforts.

24. Monitor the causes and effects of twig and branch pruning by wildlife on Serianthes nelsonii, and study if necessary.

Twig and branch removal, reportedly by birds and fruit bats, should be monitored. If monitoring shows that this is indeed a problem, a study on control methods should be initiated.

25. Study habitat requirements.

Although historic information suggests that Serianthes nelsonii occurs primarily on limestone substrates, the former presence of trees in the Tarzan River Valley and Mt. Tenjo - Mt. Alutom region of Guam, indicates that the species can grow on volcanic soils as well. However, two seedlings planted on volcanic soils in the Cotal Conservation Reserve in 1989 by the Guam Division of Forestry and Soil Resources have grown poorly (Anonymous 1991). Further work should be carried out to examine the edaphic requirements of the species. The shade tolerance of the species should be determined. Anecdotal observations on both islands suggest that seedling germination and survival are high in small clearings (Culbert 1985) or areas with open understorys (G. Wiles, personal observation 1992).

3. Augment existing populations.

Populations with only 1 to 3 remaining plants are highly unstable and probably incapable of regenerating to recovery objective levels without active augmentation.

31. Determine populations to be augmented.

The Guam population, with only a single mature tree, will need active augmentation. The possibilities for augmentation of the 16 Rota subpopulations should be evaluated. Some of these subpopulations may be combined and linked through augmentation to produce the two larger populations needed for downlisting.

32. Determine appropriate augmentation/reintroduction techniques.

Cultivation and transplantation have already been attempted by CNMI, GDAWR, the University of Guam and the Waimea Arboretum and Botanical Garden. These efforts should be continued and expanded to determine the best augmentation techniques.

33. Develop an augmentation plan for Guam.

Detailed population augmentation plans which address the specific genetic stock to be used and the precise location of all transplants should be developed.

331. Select genetic stock to be used in augmentation.

Studies should be conducted to measure the degree of genetic similarity of the Serianthes nelsonii populations on these islands. If found to be closely related, translocation of seeds and plants between the islands would be justified. If found to be distinct, consideration should be given to maintaining the two populations as separate, if possible.

332. Identify areas to augment.

Within management exclosures, specific areas must be identified as the precise anticipated locations of all transplants.

333. Propagate genetically suitable plants.

Once the genetic stock has been selected, plants must be propagated in an appropriate facility.

334. Transplant nursery-grown plants.

Once the transplant areas have been identified and the proper genetic stock propagated, transplantation can proceed. Steps should be taken to ensure that transplanting does not introduce disease to wild populations. All plants which fail to survive

transplantation will need to be replaced with genetically similar individuals.

34. Develop an augmentation plan for Rota.

See narrative under task # 33.

341. Select genetic stock to be used in augmentation.

See narrative under task # 331.

342. Identify areas to augment.

See narrative under task # 332.

343. Propagate genetically suitable plants.

See narrative under task # 333.

344. Transplant nursery-grown plants.

See narrative under task # 334.

4. Reestablish Serianthes nelsonii in former range.

At least one new subpopulation of Serianthes nelsonii must be established on Guam to reach the downlisting goal. Careful planning should precede the introduction of plants to new areas.

41. Locate suitable introduction site(s).

Using knowledge of site requirements gained from research and monitoring, sites for reestablishment that meet the plant's needs should be chosen. Such locations should be mapped and classified on the basis of feasibility for management. If possible, sites for new subpopulations should be widely distributed to reduce the chances of a catastrophic typhoon destroying a large proportion of the island's total population. The reestablishment of a subpopulation in the Tarzan River Valley or at other sites in southern Guam is highly recommended. The 60 acre exclosure which has been constructed by the Anderson Air Force Base 633 Civil Engineering squadron in the Northwest Field area may also be a good site for establishing a new subpopulation. One seedling was planted there on October 29, 1992 and was healthy as of July 26, 1993.

42. Secure site(s) identified in task # 41.

Once the reintroduction site(s) have been selected, it will be necessary to secure the site(s) through cooperative agreements with the landowner(s).

43. Fence new site(s).

See narrative under task # 1141.

44. Control insect pests in new exclosure(s).

See narrative under task # 116.

45. Control the threat of fire.

See narrative under task # 129.

46. Select genetic stock for reintroduction.

Individuals genetically similar to those used in augmentation of the current Guam population should be used for establishment of new subpopulations on Guam.

47. Introduce plants to new areas.

Once the reintroduction site(s) have been identified and secured and proper genetic stock propagated, transplantation to the site(s) can begin. All plants which fail to survive transplantation must be replaced with genetically similar individuals.

5. Validate recovery objectives.

It will be important to periodically verify the scientific validity of the recovery objectives contained in this plan. They should be updated and expanded as often as new information warrants.

51. Determine number of populations needed for long term survival.

It will be necessary to know if the required minimum of two subpopulations on each island is adequate to safeguard against catastrophic events over the next 200 years.

52. Determine number of individuals needed for long term survival.

It will be necessary to know the minimum # of individuals in each subpopulation needed to protect against catastrophic events and inbreeding suppression.

53. Revise recovery objectives.

Recovery objectives should be revised if new information suggests that the current objectives are inadequate.

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PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated cost for the Serianthes nelsonii recovery program, as set forth in this recovery plan. It is a guide for meeting the objectives discussed in Part II of this Plan. This schedule indicates task priority, task numbers, task descriptions, duration of tasks, the agencies responsible for committing funds, and lastly, the estimated costs. The agencies responsible for committing funds are not, necessarily, the entities that will actually carry out the tasks. When more than one agency is listed as the responsible party, an asterisk is used to identify the lead entity.

The actions identified in the Implementation Schedule, when accomplished, should protect habitat for the species, stabilize the existing populations and increase the population sizes and numbers on Guam and Rota. Monetary needs for all parties involved are identified to reach this point.

Priorities in Column 1 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.
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.

Key to Acronyms Used in the Implementation Schedule

GDFSR	-	Guam Division of Forestry & Soil Resources
GDAWR	-	Guam Division of Aquatic & Wildlife Resources
CNMI	-	Commonwealth of the Northern Marianas Islands
ES	-	U.S. Fish and Wildlife Service, Ecological Services
DM & JT	-	Diego Mediola and Jack Titano
USAF	-	United States Air Force
GOVGUAM	-	Government of the Territory of Guam
FWS-RES	-	U.S. Fish and Wildlife Service, Region 8, Research
UOG	-	University of Guam
WABG	-	Waimea Arboretum and Botanical Garden
AAFB	-	Andersen Air Force Base

Key to Other Codes Used in Implementation Schedule

C	-	Continuous task
O	-	Ongoing (already begun as of writing of plan)

Recovery Plan Implementation Schedule for Serianthes nelsonii

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY1993	FY 1994	FY 1995	FY 1996	FY 1997	Comments
Secure current sites:											
1	111	Confirm ownership and negotiate coop agreement for Rota subpop's 10, 12 & 13	2	CNMI	0.5		0.25	0.25			
				* ES	0.5		0.25	0.25			
1	112	Negotiate coop agreement with CNMI for Rota sub-pop's 2-9, 11 and 14-16	2	CNMI	0.5		0.25	0.25			
				* ES	0.5		0.25	0.25			
1	113	Negotiate coop agreement with Rota subpop. 1 landowners Diego Mediola and Jack Taitano	2	CNMI	0.5		0.25	0.25			
				DM & JT	0						
				* ES	0.5		0.25	0.25			
1	121	Continue negotiations for coop agreement with AAFB for Guam trees	0	GDAWR	0.5	0.25	0.25				Ongoing, awaiting outcome of Nat. Wildlife Refuge and critical habitat decisions
				USAF	0.5	0.25	0.25				
				* ES	0.5	0.25	0.25				
				UOG	0.5	0.25	0.25				
1	122	Consider coop agreement with Gov. of Guam for Tarzan River Valley site	2	GDAWR	0.5		0.25	0.25			
				GOVGUAM	0.5		0.25	0.25			
				* ES	0.5		0.25	0.25			
Manage current sites:											
1	1141	Determine areas to fence on Rota	1	CNMI	0.5		0.5				
1	1142	Fence subpop's on CNMI land	5	* CNMI	200		50	50	50	50	
				ES	200		50	50	50	50	
1	1143	Fence subpop's owned by Diego Mediola and Jack Taitano	2	* CNMI	40		20	20			
				ES	40		20	20			
1	1144	Fence subpop's owned by others	2	* CNMI	80		40	40			
				ES	80		40	40			
1	1231	Fence trees on AAFB	2	GDAWR	20		10	10			
				* USAF	60		30	30			
1	1145	Maintain fences on Rota	C	CNMI	10				5	5	
1	1232	Maintain fences on Guam	C	GDAWR	0.4				0.2	0.2	
				* USAF	0.4				0.2	0.2	
1	115	Prevent clearing near remaining trees on Rota	C	CNMI	1.3		1	0.1	0.1	0.1	
1	124	Prevent clearing near remaining trees on Guam	C	GDAWR	0.5		0.5				
				* USAF	0.5		0.5				

Recovery Plan Implementation Schedule for Serianthes nelsonii

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY1993	FY 1994	FY 1995	FY 1996	FY 1997	Comments
1	116	Control insect pests on Rota	C	CNMI	20		5	5	5	5	
1	125	Control insect pests on Guam	C	* GDFSR UOG	4		1	1	1	1	
2	117	Remove strangler figs on Rota trees	1	CNMI	5		5				
2	126	Remove strangler figs on Guam trees	1	* GDFSR USAF	1		1				
2	118	Cross-fertilize Rota trees	5	CNMI	20		5	5	5	5	
2	127	Cross-fertilize Guam trees	5	* GDFSR UOG USAF	0.4 0.4 0.4		0.1 0.1 0.1	0.1 0.1 0.1	0.1 0.1 0.1	0.1 0.1 0.1	
2	119	Consider application of fertilizer to Rota trees	1	CNMI	0.4		0.1	0.1	0.1	0.1	
2	128	Consider application of fertilizer to Guam trees	1	* GDFSR GDAWR UOG USAF	0.5 0.1 0.1 0.1		0.5 0.1 0.1 0.1				
2	1110	Determine need for wildfire control on Rota	2	CNMI	5		2.5	2.5			
2	129	Determine need for wildfire control on Guam	2	* GDAWR USAF GDFSR	0.5 0.5 0.5		0.25 0.25 0.25	0.25 0.25 0.25			
2	1111	Tag and monitor all individuals on Rota	C	CNMI	20		5	5	5	5	
2	1210	Tag and monitor all individuals on Guam	0	* GDFSR USAF GDAWR	2.5 2.5 1.25	0.5 0.5 0.25	0.5 0.5 0.25	0.5 0.5 0.25	0.5 0.5 0.25	0.5 0.5 0.25	Ongoing
2	1112	Develop additional management techniques for Rota, as needed	C	* CNMI ES	0 0		TBD TBD				
2	1211	Develop additional management techniques for Guam, as needed	C	* GDFSR ES GDAWR UOG	0 0 0 0		TBD TBD TBD TBD				
2	131	Continue surveys for new trees on Rota	0	CNMI	150	50	50	50			Ongoing

Recovery Plan Implementation Schedule for Serianthes nelsonii

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY1993	FY 1994	FY 1995	FY 1996	FY 1997	Comments
2	132	Survey for new trees on Guam	2	GDAWR	10		5	5			
				* GDFSR	10		5	5			
2	133	Include new populations in management actions	C	* GDFSR	0			TBD			
				* CNMI	0			TBD			
				GDAWR	0			TBD			
				ES	0			TBD			
2	14	Create a public education and involvement program	C	* GDAWR	8		5	1	1	1	
				* CNMI	8		5	1	1	1	
				GDFSR	4		1	1	1	1	
				UOG	4		1	1	1	1	
		Need 1 (Secure and Manage habitat)			1019.25	52.25	365.45	347.25	127.15	127.15	
2	21	Study ecology	10	FWS-RES	4		1	1	1	1	
				* GDFSR	28		7	7	7	7	
				* CNMI	28		7	7	7	7	
				UOG	56		14	14	14	14	
2	221	Study abundance and ecology of insect pests	10	FWS-RES	4		1	1	1	1	
				GDFSR	28		7	7	7	7	
				CNMI	28		7	7	7	7	
				* UOG	56		14	14	14	14	
2	222	Study seed predation by insects	10	FWS-RES	4		1	1	1	1	
				GDFSR	28		7	7	7	7	
				CNMI	28		7	7	7	7	
				* UOG	56		14	14	14	14	
2	223	Determine methods to control seed predation by insects	5	* UOG	0						
				GDFSR	0						
				CNMI	0						
2	224	Study control of mealybugs by parasitoids	5	FWS-RES	4		1	1	1	1	
				GDFSR	4		1	1	1	1	
				CNMI	4		1	1	1	1	
				* UOG	56		14	14	14	14	
2	225	Study control of ants attending mealybugs	5	FWS-RES	4		1	1	1	1	
				GDFSR	4		1	1	1	1	
				CNMI	4		1	1	1	1	
				* UOG	56		14	14	14	14	
2	23	Study threat of inbreeding suppression	5	FWS-RES	70		14	14	14	14	
				* GDAWR	5		1	1	1	1	
				CNMI	5		1	1	1	1	
2	24	If necessary, study causes and effects of branch pruning	5	FWS-RES	0		TBD				
				* GDAWR	0		TBD				
				CNMI	0		TBD				

Recovery Plan Implementation Schedule for Serianthes nelsonii

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY1993	FY 1994	FY 1995	FY 1996	FY 1997	Comments
2	25	Study habitat requirements	10	FWS-RES	4		1	1	1	1	
				* GDFSR	56		14	14	14	14	
				CNMI	4		1	1	1	1	
				UOG	56		14	14	14	14	
		Need 2 (Essential research)			684	0	167	167	167	167	
2	31	Determine populations to augment	1	* GDAWR	1		1				
				CNMI	1		1				
				ES	0.1		0.1				
2	32	Determine appropriate augmentation techniques	0	* GDFSR	15	5	5	5			Ongoing
				CNMI	15	5	5	5			
				UOG	7.5	2.5	2.5	2.5			
				WABG	7.5	2.5	2.5	2.5			
Augment Guam populations:											
2	331	Select genetic stock for augmentation on Guam	1	* GDAWR	5		5				
				CNMI	5		5				
				FWS-RES	5		5				
2	332	Identify areas to augment on Guam	1	* GDFSR	1		1				
				ES	0.1		0.1				
2	333	Propagate plants for Guam	0	* GDFSR	100	20	20	20	20	20	Ongoing
				ES	10	2	2	2	2	2	
2	334	Transplant to Guam sites	5	* GDFSR	20		5	5	5	5	
				ES	4		1	1	1	1	
Augment Rota populations:											
2	341	Select genetic stock for augmentation on Rota	1	* GDAWR	0.5		0.5				
				CNMI	0.5		0.5				
				FWS-RES	0.5		0.5				
2	342	Identify areas to augment on Rota	1	* CNMI	1		1				
				ES	0.1		0.1				
2	343	Propagate plants for Rota	0	GDAWR	10	2	2	2	2	2	Ongoing
				ES	10	2	2	2	2	2	
				* CNMI	100	20	20	20	20	20	
2	344	Transplant to Rota sites	5	* GDFSR	15			5	5	5	
				ES	3			1	1	1	
		Need 3 (Augment existing populations)			337.8	61	87.8	73	58	58	
2	41	Locate suitable introduction sites	1	* GDFSR	5		5				
				CNMI	5		5				
				ES	1		1				

Recovery Plan Implementation Schedule for Serianthes nelsonii

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000's) FY1993	FY 1994	FY 1995	FY 1996	FY 1997	Comments
2	42	Secure new sites	1	* ES	0.5		0.5				
				GDAWR	0.5		0.5				
2	43	Fence new sites	2	* GDAWR	40		20	20			
				ES	40		20	20			
2	44	Control insects at new sites	C	* GDFSR	4		1	1	1	1	
				UOG	4		1	1	1	1	
2	45	Control the threat of fire	C	GDFSR	4		1	1	1	1	
2	46	Select genetic stock for reintroduction	1	* GDAWR	5		5				
				FWS-RES	5		5				
2	47	Introduce to new areas	5	* GDFSR	80		20	20	20	20	
				ES	8		2	2	2	2	
		Need 4 (Reestablish in former range)			202	0	87	65	25	25	
3	51	Determine # of populations needed for long term survival	2	* ES	0						
				GDAWR	0						
				CNMI	0						
				UOG	0						
3	52	Determine # of individuals needed for long term survival	2	* ES	0						
				GDAWR	0						
				CNMI	0						
				UOG	0						
3	53	Revise recovery objectives	1	ES	0						
		Need 5 (Validate recovery objectives)			0	0	0	0	0	0	
		TOTAL YEARLY COST			2243.05	113.25	707.25	652.25	377.15	377.15	

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