



U.S. Fish and Wildlife Service

# Final Recovery Plan

*For Three Plant Species on  
Nihoa Island*



*Line drawing of  
Amaranthus brownii  
from Wagner et al. (1990)*

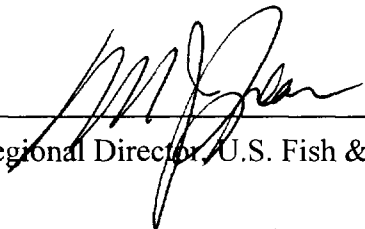
**March 1998**

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**FINAL RECOVERY PLAN FOR**  
**THREE PLANT SPECIES**  
**ON NIHOA ISLAND**

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## DISCLAIMER PAGE

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## **ACKNOWLEDGMENTS**

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## EXECUTIVE SUMMARY

**Current Species Status:** This plan covers three plant taxa, all of which are federally listed as endangered. The numbers of known remaining populations and individuals are as follows (# of colonies, # of individuals): *Amaranthus brownii* (no common name (NCN)) (4, less than 40), *Pritchardia remota* (loulou) (4, 680), and *Schiedea verticillata* (NCN) (10, 359).

**Distributions:** All of these taxa are believed to be endemic to the island of Nihoa, in the Northwestern Hawaiian Islands. However, five uncollected palms, no longer extant (in existence), were observed growing on Laysan Island in 1859 and may have been *Pritchardia remota*.

**Habitat Requirements and Limiting Factors:** The three taxa included in this plan grow only on Nihoa, which has an area of 0.65 square kilometer (0.25 square mile). When last observed in 1983, *Amaranthus brownii* was found growing on ridges in shallow soil on rocky, exposed, outcrops at elevations between 30 to 242 meters (100 to 800 feet). Most of the *Pritchardia remota* are found in two valleys, at elevations between 15 to 151 meters (50 to 500 feet). *Schiedea verticillata* grows in soil pockets and cracks on coastal cliff faces at elevations between 30 to 242 meters (100 to 800) feet.

Due to the small number of existing individuals and their extremely limited distributions, these taxa and all of their populations are subject to an increased likelihood of extinction and/or reduced reproductive vigor from random, naturally occurring events. These taxa and their habitats have been variously affected or are currently threatened by one or more of the following: fire; potential habitat degradation and competition with alien plants; predation by rodents that could easily be introduced by shipwrecks; introduced insects, possibly leading to predation on plants and loss of pollinators; and natural events such as landslides, erosion, rockslides, and flash floods.

**Recovery Objectives:** Delist all taxa. Interim, downlisting, and delisting criteria are provided. The numbers of colonies and individuals given in the objectives below should provide for the maintenance of genetic diversity and provide some

assurance that a single catastrophic event will not cause extinction of an entire taxon. These numbers may change as more is learned about the life history and as population modeling is conducted. This recovery plan should be revised as new information is gathered.

### **Recovery Criteria:**

#### **Interim Objectives**

At least three colonies of *Amaranthus brownii* should be documented on Nihoa. Each of these colonies must be naturally reproducing with a minimum of 100 mature individuals per colony (minimum total of 300 mature plants). Mature individuals are defined as those either known or believed to be capable of reproduction. Colonies of *Pritchardia remota* and *Schiedea verticillata* are apparently stable. A monitoring program should be established to monitor their status and threats twice annually. The major threats to all three taxa must also be determined and controlled, and all three taxa must be fully represented in *ex situ* (at other than its original site, such as a nursery or arboretum) collections. *Ex situ* collections should maintain the maximum number of genetically distinct individuals practical.

#### **Downlisting Objectives**

Interim objectives must have been attained. In addition, a total of at least five colonies of each taxon should exist on Nihoa and successful propagation and outplanting *ex situ* must be underway for each taxon. Each of these must be stable, secure, and naturally reproducing. Colony sizes on Nihoa should be increased with caution, and only if there is good evidence that Nihoa can support additional colony growth without negative ecological impacts. This is a concern because of Nihoa's small size and its relatively intact, native ecosystem. Colony sizes will ultimately be determined by the carrying capacity of the site where they are grown.

However, a preliminary target level is a minimum of 100 mature individuals per colony for *Pritchardia remota*, a minimum of 300 mature individuals per colony for *Schiedea verticillata*, and a minimum of 500 mature individuals per colony for *Amaranthus brownii*. Each colony should be stable or increasing for a

minimum of 5 consecutive years before downlisting is considered. The need for continued species-specific management actions should not preclude downlisting.

As a component of threat control, a remote monitoring system should be installed on Nihoa to detect and record illegal landings and ship wrecks on the island and relay the information to Refuge staff in Honolulu.

### **Delisting Objectives**

Downlisting objectives must have been obtained. Delisting for any of these three taxa may require the establishment of one to three additional colonies on an island other than Nihoa. In the case of *Pritchardia remota*, Laysan Island should be considered, since a palm that may have been this species formerly occurred there. For *Schiedea verticillata* and *Amaranthus brownii*, Necker Island should be considered since it is adjacent to Nihoa, has similar habitat, and is protected as a U.S. Fish and Wildlife Service refuge. Kilauea Point and Midway Atoll National Wildlife Refuges should also be assessed for suitability since they are protected areas, have plant nursery facilities, and have full time staffs. Midway has a similar climate to Nihoa and Kilauea Point also has north-facing cliffs similar to those on Nihoa.

Should establishment of one to three colonies of any or all of these taxa on an island other than Nihoa occur, delisting may be considered when they have reached the same targets as those described for downlisting. These targets are: a minimum of 100 mature individuals per colony for *Pritchardia remota*, a minimum of 300 mature individuals per colony for *Schiedea verticillata*, and a minimum of 500 mature individuals for *Amaranthus brownii*. Each colony should be stable or increasing for a minimum of 5 consecutive years.

If the establishment of any or all of these taxa on a second island proves unfeasible, delisting may be considered if the downlisting objectives have been met and the colonies persist at target levels for a minimum of 10 years.

In order to initiate delisting in any of the above situations, there should no longer be a need for continued species-specific management actions, but delisting may proceed if there is a continuing need for ecosystem-wide management actions.



**Actions Needed:**

1. Protect habitat and control threats.
2. Conduct research essential to conservation of the species.
3. Increase numbers and locations of *Amaranthus brownii*.
4. Establish *Pritchardia remota* on Laysan Island.
5. Evaluate potential for establishing taxa outside their historical ranges.
6. Validate and revise recovery objectives.

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

<u>Year</u>	<u>Need 1</u>	<u>Need 2</u>	<u>Need 3</u>	<u>Need 4</u>	<u>Need 5</u>	<u>Need 6</u>	<u>Total</u>
1998	177.0	348.0	0.0	10.0	40.0	14.0	589.0
1999	80.0	348.0	0.0	10.0	40.0	14.0	492.0
2000	80.0	308.0	0.0	24.0	20.0	14.0	446.0
2001	80.0	198.0	30.0	9.0	240.0	14.0	571.0
2002	80.0	10.0	30.0	9.0	240.0	14.0	383.0
2003	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2004	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2005	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2006	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2007	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2008	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2009	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2010	80.0	10.0	10.0	9.0	40.0	2.0	151.0
2011	80.0	10.0	10.0	9.0	40.0	2.0	151.0
<u>2012</u>	<u>80.0</u>	<u>10.0</u>	<u>10.0</u>	<u>9.0</u>	<u>40.0</u>	<u>2.0</u>	<u>151.0</u>
Total	1297.0	1312.0	160.0	152.0	980.0	90.0	3991.0

Some costs are still to be determined.

**Date of Recovery:** Downlisting may be considered in 2008, if all the downlisting criteria have been met. Delisting will be considered in 2012, if all recovery objectives have been met. However, estimates of recovery time may change as more is learned about the biology and population dynamics of the Nihoa plant taxa.

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# INTRODUCTION

## A. Brief Overview

This recovery plan covers three endangered plant taxa endemic to the island of Nihoa in the Northwestern Hawaiian Islands. *Amaranthus brownii*, an annual herb, *Pritchardia remota*, a palm, and *Schiedea verticillata*, a perennial herb, were listed as endangered on September 20, 1996 (61 FR 43178-43184).

The Northwestern Hawaiian Islands (NWHI) are a chain of islands that extend about 1,600 kilometers (1,000 miles) from Nihoa Island northwest to Kure Atoll (Figure 1). Nihoa is the closest to the main islands, 275 kilometers (170 miles) northwest of Kauai and about 400 kilometers (250 miles) northwest of Oahu, Hawaii. The NWHI are the oldest islands in the Hawaiian chain. They are remnants of once larger islands that have slowly eroded and subsided, which today exist as small land masses, or coral atolls that cover the remnants of the volcanic islands.

Nihoa Island, which has an area of only 0.65 square kilometer (0.25 square mile), is owned by the U.S. Fish and Wildlife Service (Service) and is managed as part of the Hawaiian Islands National Wildlife Refuge. Nihoa is also within the boundaries of the City and County of Honolulu and the State of Hawaii, and is also classified by the State as Conservation District land. Lands in these districts are regarded as necessary for the protection of endemic biological resources and the maintenance or enhancement of the conservation of natural resources (Hawaii Revised Statutes Chapter [HRS], sect. 205-2).

The three plant taxa covered by this plan have probably always been rare and restricted to the island of Nihoa, although *Pritchardia remota* may have once occurred on Laysan Island. Their current habitat is protected as a national wildlife refuge and is uninhabited by humans. The Service manages the Refuge for perpetuation of native species and regularly monitors the island for evidence of alien species incursions and other possible threats to its fragile ecosystem.

The objective of this plan is to provide a framework for the recovery of these three taxa so that their protection by the Endangered Species Act (ESA) is no longer necessary. Part I of this plan is constructed in a species-by-species

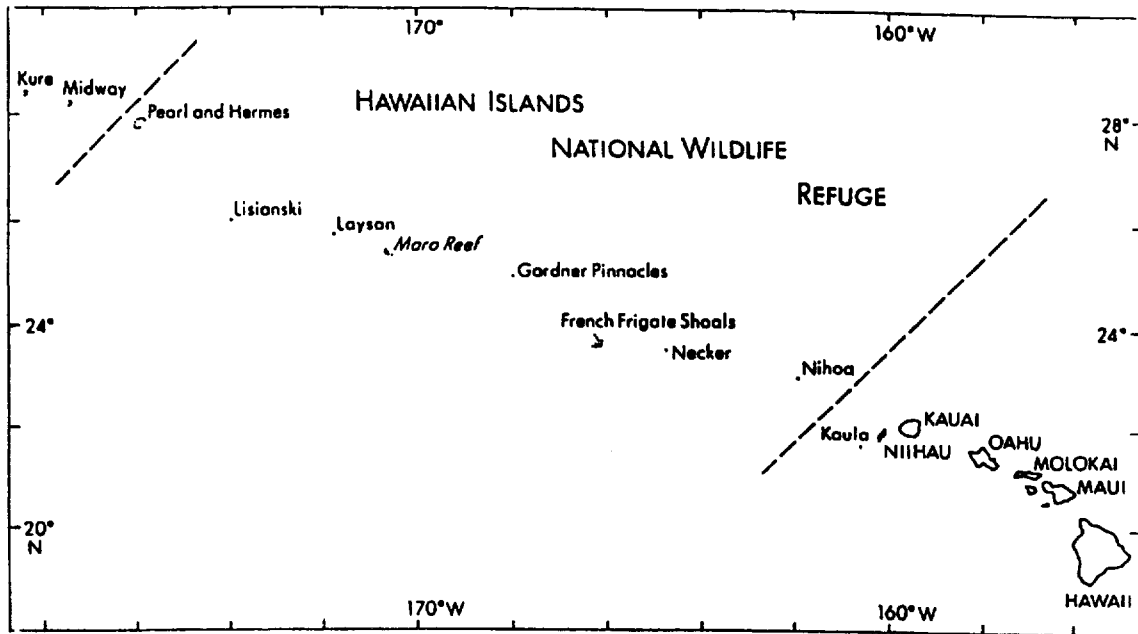


Figure 1. Map of the Northwestern Hawaiian Islands.

format with all the information about a particular species in one section. It provides a comprehensive analysis of threats to these taxa as well as a species-by-species analysis of recovery actions needed for stabilization and recovery. Part II details recovery actions necessary to stabilize, downlist, and delist the species. Part III contains a detailed implementation schedule for achieving recovery objectives. Appendix A lists agencies and peer reviewers. Appendix B contains line drawings of two of the plant species covered by this plan. Appendix C includes maps of current plant distributions. Appendix D explains the Recovery Priority System and Appendix E summarizes comments received during review of the draft plan.

## **B. General Description of Habitat**

Nihoa is the highest of the uninhabited islands of Hawaii (Figure 2). Over many years, waves driven by prevailing trade winds eroded the island into its current shape, which is the remnant southwest quadrant of the original huge volcanic cone. The east, west, and north sides of Nihoa are sheer cliffs, and the south coast comprises low cliffs with rock benches and one small beach (Cleghorn 1987, Gagne and Conant 1983, Macdonald *et al.* 1983). The island, formed about 7.5 million years ago by a single shield volcano, now measures only 1.4 kilometers (0.85 mile) long, an average of 0.5 kilometer wide (0.3 mile), and 63.1 hectares (156 acres) in area (Macdonald *et al.* 1983, Walker 1990). The highest point, 273 meters (896 feet) in elevation (Conant 1985), is located at one of the two peaks on Nihoa, which are separated by a depression dissected by six valleys (Macdonald *et al.* 1983). The elevation of the island is not sufficient to increase precipitation from that which would fall on a flat island, and the yearly rainfall of 51 to 76 centimeters (20 to 30 inches), usually concentrated in the winter months, is the result of unpredictable rain squalls passing over the island (Carlquist 1980, Cleghorn 1987). Valleys are deep and have little sediment, indicating that their streams were once powerful, but the only water on the island now is found in three freshwater seeps (Cleghorn 1987).

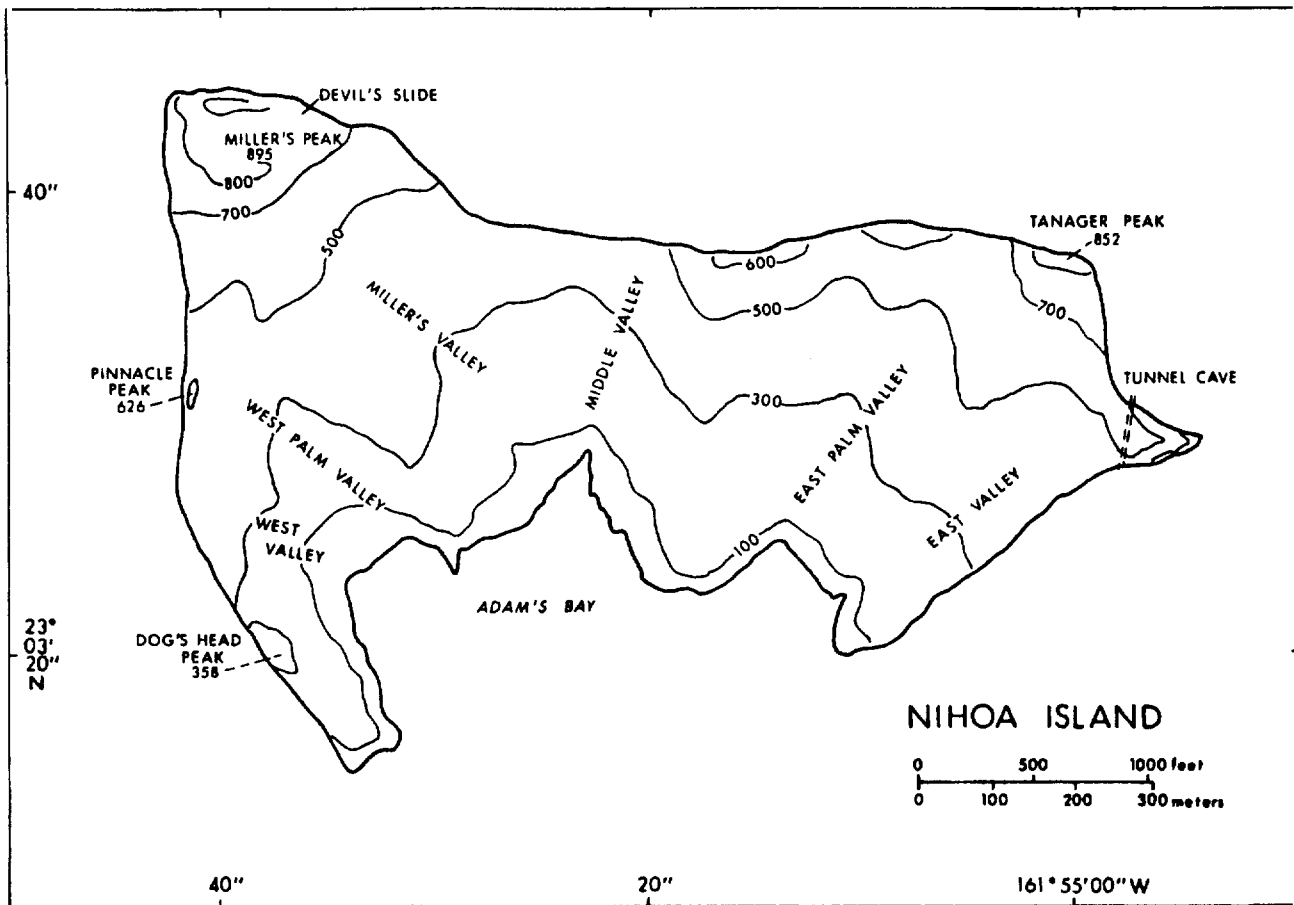


Figure 2. Map of Nihoa Island



Nihoa, with the most diverse flora and fauna of any of the NWHI, represents a relatively intact low-elevation dryland ecosystem with a complement of native plants, arthropods, and birds (Gagne 1982). Several species associated with Nihoa are, however, listed as threatened or endangered (see Table 1). Low-elevation dryland ecosystems were probably common in the main Hawaiian islands prior to their disturbance by Polynesian agricultural practices (Cuddihy and Stone 1990). Nihoa was inhabited beginning in the thirteenth century by a small group of Polynesian settlers, who terraced and cultivated most of the gently sloping area of the island, a total of 4.9 to 12.5 hectares (12 to 31 acres) or 7.7 to 20 percent of the area of the island. Most of the island was unsuitable for cultivation, and habitation did not persist for a long period of time, so much of the natural ecosystem remained intact (Cleghorn 1987, Emory 1928, Harrison 1990). It is unknown what impacts agriculture may have had on the endangered taxa, although it may have reduced their numbers. Animals now found on or near Nihoa include: a small, resident population of Hawaiian monk seals (*Monachus schauinslandi*), a listed endangered species; green sea turtles (*Chelonia mydas*), a listed threatened species; 17 species of breeding seabirds; several species of migratory shorebirds; 2 species of endemic land birds, Nihoa millerbird (*Acrocephalus familiaris*) and Nihoa finch (*Telespiza ultima*), both listed endangered species; 6 species of endemic land snails; and 35 endemic and 26 indigenous arthropods, many only recently discovered.

A total of 26 vascular plant taxa have been found on Nihoa: 3 endemic to the island, 17 indigenous to Hawaii, and 6 alien taxa. The three endemic taxa are the subjects of this recovery plan: *Amaranthus brownii*, *Pritchardia remota* (loulou), and *Schiedea verticillata*. The 17 Hawaiian indigenous taxa are: *Chamaesyce celastroides* var. *celastroides* (akoko), *Chenopodium oahuense* (aheahea), *Eragrostis variabilis* (kawelu), *Panicum torridum* (kakonakona), *Portulaca villosa* (ihi), *Rumex albescens* (huahuako), the endangered *Sesbania tomentosa* (ohai), *Sicyos pachycarpus* (kupala), *Solanum nelsonii* (popolo), *Boerhavia diffusa* (alena), *Heliotropium curassavicum* (seaside heliotrope), *Ipomoea indica* (koaliawa), *Ipomoea pes-caprae* ssp. *brasiliensis* (pohuehue), *Portulaca lutea* (ihi), *Sida fallax* (ilima), *Solanum americanum* (glossy nightshade), and *Tribulus cistoides* (nohu). The six alien species are: *Cenchrus*

Table 1. Listed Threatened and Endangered Nihoa Species and Associated Recovery Plans

SPECIES	RECOVERY PLAN
<i>Monachus schauinslandi</i> (Hawaiian monk seal)	NMFS. 1983. <i>Recovery Plan for the Hawaiian Monk Seal, Monachus schauinslandi</i> . NMFS, Terminal Island, CA.
<i>Chelonia mydas</i> (green sea turtle)	U.S. Pacific Sea Turtle Recovery Team. 1995. <i>Draft Recovery Plan for U.S. Pacific Populations of the Green Turtle</i> . NMFS and USFWS, Washington, D.C.
<i>Acrocephalus familiaris kingi</i> (Nihoa millerbird) and <i>Telespiza ultima</i> (Nihoa finch)	USFWS. 1984. <i>Recovery Plan for the Northwestern Hawaiian Islands Passerines</i> . USFWS, Portland, OR.
<i>Sesbania tomentosa</i> (ohai)	USFWS. 1996. <i>Draft Recovery Plan for the Multi-Island Plant Cluster</i> . USFWS, Portland, OR.

*echinatus* (common sandbur), *Nephrolepis multiflora* (sword fern), *Paspalum* sp., *Portulaca oleracea* (pigweed), *Setaria verticillata* (bristly foxtail), and *Tetragonia tetragonioides* (New Zealand spinach) (Conant 1985, Conant and Herbst 1983, Gagne and Conant 1983, Harrison 1990, Herbst 1977). By far the most common of these alien taxa on Nihoa is pigweed.

Bare rock and unvegetated soil make up about one-third of the surface of Nihoa. All vegetation is classified as being part of Coastal Communities, including Coastal Dry Communities and a Coastal Mesic Community. Table 2 summarizes Nihoa habitat types and associated plant species. Coastal Dry Shrublands include two forms of Ilima (*Sida*) Shrubland: prostrate plants near the shore and erect plants in more sheltered sites. The Aweoweo (*Chenopodium* or aheahea) Coastal Shrubland includes aheahea and popolo as codominants, as well as ilima and several other less frequent species. Coastal cliff faces, another type of Coastal Dry Shrubland present on Nihoa, include kawelu (*Eragrostis*) as a dominant species. The Loulu (*Pritchardia*) Coastal Forest, a type of Coastal Mesic Forest, contains *Pritchardia remota* as the only dominant (Gagne and Cuddihy 1990).

### **C. Overall Reasons for Decline and Current Threats**

Competition with alien plants is the primary threat to the three endangered Nihoa plant taxa covered by this plan. Introduced plant species often out-compete native species for space, light, water, and nutrients. Caution on the part of personnel working on the island and frequent monitoring of the vegetation and removal of alien plants have helped keep established alien plant taxa to a minimum on Nihoa (Conant 1983a, 1983b, 1985; Herbst 1980; Marshall 1964). However, six alien plant species have been reported on the island of Nihoa since the early 1960's. One of these taxa, pigweed, is now widespread over the entire island and is displacing native vegetation in the habitat of *Amaranthus brownii* and *Schiedea verticillata*.

Rats (*Rattus* spp.) and house mice (*Mus musculus*), which have been transported by humans to several small islands and islets in the Hawaiian chain

Table 2. Summary of Nihoa Habitat Types and Associated Plant Species

Habitat Type	Nihoa Plant Recovery Plant Species	Associated Native Plant Species	Associated Alien Plant Species
<b>Coastal Dry Shrubland</b>	<i>Amaranthus brownii</i> (NCN)	<i>Chenopodium oahuense</i> (aheahea) <i>Ipomoea pes-caprae</i> ssp. <i>brasiliensis</i> (pohuehue) <i>Ipomoea indica</i> (koaliawa) <i>Sicyos pachycarpus</i> (kupala) <i>Eragrostis variabilis</i> (kawelu) <i>Sida fallax</i> (ilima) <i>Solanum nelsonii</i> (popolo) <i>Panicum torridum</i> (kakonakona) unidentified lichens	<i>Portulaca oleracea</i> (pigweed) <i>Tetragonia tetragoniodes</i> (New Zealand spinach)
<b>Coastal Mesic Forest</b>	<i>Pritchardia remota</i> (loulou)	<i>Chenopodium oahuense</i> (aheahea) <i>Sesbania tomentosa</i> (ohai) <i>Solanum nelsonii</i> (popolo) <i>Sida fallax</i> (ilima) unidentified lichens	none
<b>Coastal Cliff Faces</b>	<i>Schiedea verticillata</i> (NCN)	<i>Rumex albescens</i> (huahuako) <i>Tribulus cistoides</i> (nohu) <i>Eragrostis variabilis</i> (kawelu)	<i>Portulaca oleracea</i> (pigweed)

(Tomich 1986), could be accidentally introduced to Nihoa by visiting recreational boaters and fishing vessels. Rodent predation of seeds of other *Pritchardia* species has been well documented and could prove disastrous for *Pritchardia remota* (Center for Plant Conservation (CPC) 1990b, Cuddihy and Stone 1990). The fleshy root of *Schiedea verticillata* may also prove palatable to rodents (CPC 1990a).

Over 70 species of alien insects have been documented on Nihoa (Beardsley 1966; Bryan 1978; Conant *et al.* 1984; Conant 1997). Carmine spider mites (*Tetranychus cinnabarinus*) have been collected several times on Nihoa and could threaten *Schiedea verticillata* (CPC 1990a). Conant (1997) also reported finding several alien insect species in 1996, including ants, and three previously unreported pest species: the silverleaf whitefly (*Bemisia argentifolia*), the chrysanthemum leafminer (*Liriomyza trifolii*), and the oriental fruit fly (*Bactrocera dorsalis*). He also reported high numbers of the phoenicococcid, *Platyoccus tylocephalus*, on the leaves of older *Pritchardia remota* plants. Research by Male and Loeffler (1997) on several species of *Pritchardia* indicate that many species of insects, mostly aliens, feed on the seeds and fruit of *Pritchardia* in the main Hawaiian Islands. In addition to potentially damaging native plants and seeds, introduced insect species may reduce or eliminate native insects that serve as pollinators.

Loss of insect and bird pollinators is a possible threat to all of the Nihoa taxa. Research to determine the presence/absence and nature of appropriate pollinators for each of the Nihoa taxa will be essential to their recovery.

The very limited range and small populations of the endangered Nihoa plant taxa greatly increase the potential for extinction of these species from stochastic events. *Amaranthus brownii* and *Pritchardia remota* have only four colonies each and *Amaranthus* is believed to number fewer than 40 individuals. The limited gene pool of all three taxa may depress reproductive vigor.

Erosion, landslides, rock slides, and flooding due to natural or human-related causes could result in deaths of individuals, destruction of habitat, and, possibly, extirpation of entire colonies or populations of these taxa. *Pritchardia remota* grows on valley floors and at the bases of basaltic cliffs, areas that are subject to flash floods (Kramer 1962). *Amaranthus brownii* grows on rocky outcrops and *Schiedea verticillata* typically grows on coastal cliff faces, making both of these taxa particularly susceptible to landslides and rockslides.

Due to low amounts of rainfall, Nihoa's vegetation is often dry and very susceptible to fire. An 1885 trip to Nihoa by a group led by Queen Liliuokalani illustrates this vulnerability. The group had to leave the island abruptly after they started a fire which quickly swept across the island (Culliney 1988). Fires caused by smoking or cooking remain potential threats.

Because of the steep slope and rocky nature of Nihoa, people walking from place to place on the island can cause a great deal of damage. Currently, the only legal visitors are those with Service approval, usually refuge personnel or scientific researchers who are very aware of the fragile nature of the island's environment (Conant 1985). With increased commercial fishing in the NWHI, there is a greater possibility of mishaps and unauthorized landings on Nihoa (Gagne and Conant 1983). Recreational boaters might be tempted to land illegally on the island. Incidents occurred in 1981 and 1990 in which people on a yacht had an inflatable boat ready to approach the island, but, upon seeing the camp of researchers working on the island, made a hasty retreat (Sheila Conant, University of Hawaii, personal communication 1991; Craig Rowland, USFWS, personal communication 1997). Table 3 illustrates the numerous immediate and potential threats to the Nihoa plants.

#### **D. Overall Conservation Efforts**

##### **1. Federal and State Efforts**

The three taxa included in this plan were listed under the ESA as endangered on September 20, 1996 (61 FR 43178-43184). When a species is listed as endangered or threatened under the ESA, it is automatically added to the State of Hawaii's list of protected species (Hawaii Revised Statutes Chapter [HRS] 195D). Hawaii State law prohibits taking of endangered flora and encourages conservation by State government agencies. ("Take" as defined by Hawaii State law means "to harass, harm..., wound, kill..., or collect endangered or threatened... species... or to cut, collect, uproot, destroy, injure, or possess endangered or threatened... species of... land plants, or to attempt to engage in any such conduct"[HRS 195D].) The ESA offers additional Federal protection to these taxa since it is a violation of the ESA for any person to remove, cut, dig up,

Table 3. Summary of Threats to Nihoa Plants

SPECIES	Rats	Alien plants	Fire	Alien insects	Substrate loss <sup>1</sup>	Limited numbers <sup>2</sup>
<i>Amaranthus brownii</i>	P	X	P	P	P	Xa,b
<i>Pritchardia remota</i>	P	P	P	P	P	Xa
<i>Schiedea verticillata</i>	P	X	P	P	X	P

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**KEY**

1 = Substrate loss includes erosion, rock slides, flash floods, and landslides.

2 = No more than 100 individuals and/or no more than 5 populations.

X = Immediate and significant threat.

P = Potential threat.

a = No more than 5 populations.

b = No more than 50 individuals.

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damage, or destroy an endangered plant in an area not under Federal jurisdiction in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law [Section 9(a)(2) of the ESA].

Because the three taxa are on a national wildlife refuge, ongoing management includes monitoring of populations and potential pests, and weeding of alien plants. However, current levels of refuge funding and the difficulty of travel logistics allow only a maximum of one short visit per year. Management must be intensified to achieve recovery objectives for these species.

Critical habitat was not designated for any of the Nihoa taxa. It was not deemed prudent because the taxa are located within the boundaries of a national wildlife refuge, one of the policies of which is to conserve native vegetation. Another reason critical habitat was not designated was the possibility of increased threat to the plants by vandalism, researchers, curiosity seekers, or collectors of rare plants due to the mandated publication of precise maps and descriptions of critical habitat in local newspapers.

## 2. Non-Governmental Efforts

Several botanical gardens have plants or seeds of *Pritchardia remota* and *Schiedea verticillata* in their collections (see Table 4). However, attempts to grow *Amaranthus brownii* in cultivation have not succeeded, with only a few seeds germinating and those seedlings not surviving (Conant 1985). This may be an indication of overall reduced viability of the taxon. There are no records of *Amaranthus brownii* seeds or plants currently in the possession of any botanical garden. Micropropagation of tissues (cloning) or seed embryos may be the only viable method for propagating this species (S. Conant, personal communication 1997).

Seeds or plants of *Pritchardia remota* and/or *Schiedea verticillata* are kept at the National Tropical Botanical Garden (NTBG), Waimea Arboretum, Lyon Arboretum, Honolulu Botanical Gardens, and the University of California at Irvine. *Pritchardia remota* seeds do not store well and, therefore, stocks of *Pritchardia* seeds are not maintained by any of the botanical gardens. Propagation must be conducted very carefully, to avoid pollination by other species of *Pritchardia* (Woolliams, personal communication 1997). The breeding



Table 4. Nihoa Plants and Seeds in Botanical Gardens

SPECIES	Waimea Arboretum	Lyon Arboretum	NTBG	Honolulu Botanical Gardens (all sites)	UC Irvine
<i>Amaranthus brownii</i>	none	none	none	none	none
<i>Pritchardia remota</i>	4 plants	3 plants	27 plants	35 plants	none
<i>Schiedea verticillata</i>	6 plants	none	250 seeds	none	9 plants

Note: Some of the *Schiedea verticillata* in this table are derived from cuttings from the same parent plant and are genetically identical. Also, some of the *Pritchardia remota* are from accessions that have been in cultivation for one or more generations.

history of any stock considered for use in reintroductions should be carefully screened to eliminate any potential hybrids. Another factor to consider is that many of the *Pritchardia remota* in collections have been grown from seeds of trees grown in cultivation for one or more generations. Therefore, they were not subjected to the same selective pressures as plants in the wild and may not be as competitive as wild stock if reintroduced to Nihoa.

A small number of *Schiedea verticillata* exist in cultivation. Cultivation of this species has been hampered in the past by die-offs of seedlings (termed “damping off”) due to a fungal disease. However, this problem can probably be controlled by using sterile soil and maintaining cool, low humidity conditions during and after germination (Woolliams, personal communication 1997).

### **E. Overall Recovery Strategy**

The plan for recovery is detailed in the step-down narrative in Part II. Because Nihoa is within a national wildlife refuge, designation of additional protective land status is not necessary. However, a critical need for all three taxa is a stepped-up monitoring program aimed at assessing the status and health of the populations and minimizing threats to the taxa. Additionally, seeds and tissues of all three taxa should be collected, accompanied by research on long-term storage of seeds, propagation and micropropagation, and outplanting techniques. A research program is also recommended to study the growth and reproductive viability of each taxon, determine the parameters of viable populations of each taxon, study the reproductive strategy and pollinators of each taxon, study possible pests and diseases, and use the results of such research to improve management practices.

A program to increase existing wild populations, and possibly introduce new populations of some or all three Nihoa taxa on other Hawaiian Islands is also needed. This program includes selection of areas for augmentation and establishment, assessment of any negative ecological impacts caused by establishing taxa on other Hawaiian islands, determination of the best methods for *ex situ* propagation and transplanting, selection of the best genetic stock for each area, propagation of suitable stock, protection and preparation of sites for seeding and/or transplanting, and monitoring and maintenance of new individuals and populations as they are established.

Potential locations for establishing new populations of Nihoa plants include Necker, Laysan, Midway, and Kauai. Considerable research will have to be done to determine which, if any, of these locations are acceptable.

Finally, the recovery objectives should be refined and revised as new information becomes available.

## **F. Species Accounts**

Much of the information in this section was taken directly from the listing package for these taxa (61 FR 43178-43184).

### **1. *Amaranthus brownii***

**(No common name) Recovery Priority Number 5**

(Recovery Priority Number system is described in Appendix D)

#### **a. Description and Taxonomy**

*Amaranthus brownii* is the only member of this genus found in the Hawaiian Islands and is endemic to Nihoa. It was first collected by Edward L. Caum during the Tanager Expedition in 1923. Erling Christophersen and Caum named it in honor of Dr. F.B.H. Brown in 1931.

*Amaranthus brownii*, a member of the amaranth family (Amaranthaceae), is an annual herb with leafy upright or ascending stems, 30 to 90 centimeters (1 to 3 feet) long (see Appendix B for line drawing). The slightly hairy, alternate leaves are long and narrow, 4 to 7 centimeters (1.6 to 2.8 inches) long, 1.5 to 4 millimeters (0.06 to 0.16 inch) wide, and more or less folded in half lengthwise. Flowers are either male or female, and both sexes are found on the same plant. The green flowers are subtended (embraced) by two oval, bristle-tipped bracts about 1 millimeter (0.04 inch) long and 0.7 millimeter (0.03 inch) wide. Each flower has three bristle-tipped sepals which are lance-shaped and 1.3 millimeters (0.05 inch) long by 0.8 millimeter (0.03 inch) wide in male flowers and spatula-shaped and 0.8 to 1 millimeter (0.03 to 0.04 inch) long by 0.2 to 0.5 millimeter (0.01 to 0.02 inch) wide in female flowers. Male flowers have three stamens; female flowers have two stigmas. The flattened, oval fruit, which does not split open at maturity, is 0.8 to 1 millimeter (0.03 to 0.04 inch) long and 0.6 to 0.8

millimeter (0.02 to 0.03 inch) wide and contains one shiny, lens-shaped, reddish black seed. This species can be distinguished from other Hawaiian members of the genus by its spineless leaf axils, its linear leaves, and its fruit which does not split open when mature (Wagner *et al.* 1990).

b. Life History

*Amaranthus brownii* is a herbaceous annual with a growing season that extends from December to June or July. Conant (1985) reported finding plants in an early stage of flowering in February and collecting seed from dead plants during June. Phenology may vary somewhat from year to year, depending on rainfall and climatic factors. The means of pollination are unknown.

c. Habitat Description

*Amaranthus brownii* typically grows in shallow soil on rocky outcrops. It is found in fully exposed locations at elevations between 30 and 242 meters (100 and 800 feet). Associated native plant taxa include *Schiedea verticillata*, *Chenopodium oahuense*, *Ipomoea pes-caprae* ssp. *brasiliensis*, *Ipomoea indica*, *Sida fallax*, *Solanum nelsonii*, *Sicyos pachycarpus*, *Eragrostis variabilis*, and *Panicum torridum*.

d. Historic and Current Ranges and Population Status

*Amaranthus brownii* is the rarest native plant on Nihoa (Conant 1985). When it was first collected in 1923, it was "most common on the ridge leading to Miller's Peak, but abundant also on the ridges to the east" (Herbst 1977). In 1983, the 2 known groupings of colonies were separated by a distance of 0.4 kilometer (0.25 mile) and contained approximately 35 plants: 1 colony of about 23 plants near Miller's Peak and about 12 plants in 3 small colonies in Middle Valley. No plants have been seen at either location since 1983, even though Service staff have surveyed for them annually (Kenneth McDermond and Elizabeth Flint, *in litt.*, 1993; C. Rowland, personal communication 1997). However, none of the surveys since 1983 have been done during the winter, when these annuals are easiest to find and identify. In order to get an accurate population count and collect seeds

or cuttings to establish *ex situ* populations, it will be necessary to conduct winter surveys.

e. Reasons for Decline and Current Threats

This species may have experienced a reduction in total numbers due to disturbances resulting from Polynesian settlement of Nihoa. Pigweed, an alien species, is widespread on Nihoa and grows in habitat similar to *Amaranthus brownii*. Pigweed may pose a threat by outcompeting *Amaranthus* for space, moisture, and nutrients. Other alien plant and insect species on the island may be posing threats as well. Because it grows on rocky outcrops, *Amaranthus brownii* is likely to be affected by substrate changes. Fire, introduction of rats, and other human disturbances also pose potential threats. Due to the small numbers of populations and individuals, and its limited distribution, this species is threatened by stochastic extinction and/or reduced reproductive vigor.

f. Conservation Measures

Seeds have been collected for cultivation, but resulting germination and survival rates were very low. This may indicate a reduction in the reproductive vigor of the species (Hawaii Heritage Program (HHP) 1990a1, 1990a2; Wagner *et al.* 1985, 1986, 1990). There are no known plants or seeds in any botanical collection.

g. Needed Recovery Actions

Immediate recovery actions should include a winter expedition to monitor and map remaining populations and to collect seeds and/or cuttings to establish *ex situ* populations. Micropropagation techniques developed at the Lyon Arboretum in Honolulu are probably the best prospect for culturing sufficient material to establish *ex situ* populations and reestablish the species in the wild.

Increasing the numbers and locations of this species on Nihoa will be critical to its ultimate survival and recovery. Considerable work will need to be done to identify, prepare, protect, and monitor sites for establishing new wild populations, particularly if the sites are outside of the historic range. Necker

Island should be considered since it is adjacent to Nihoa, has similar habitat, and is protected as a U.S. Fish and Wildlife Service refuge. Kilauea Point and Midway Atoll National Wildlife Refuges should also be assessed for suitability since they are protected areas, have plant nursery facilities, and have a full time staff.

## **2. *Pritchardia remota***

### **(loulu) Recovery Priority Number 2**

(Recovery Priority Number system is described in Appendix D)

#### a. Description and Taxonomy

In 1858, Dr. Rooke brought seed of a palm from Nihoa and planted it on the palace grounds in Honolulu (Hillebrand 1888). A Hillebrand specimen, probably collected from this cultivated tree, was used by Odoardo Beccari (1890) to describe *Pritchardia remota*. Otto Kuntze transferred the species to other genera, resulting in *Washingtonia remota* (Kuntze 1891) and later *Eupritchardia remota* (Beccari and Rock 1921). In their 1921 monograph of the genus, Beccari and Joseph Rock included the species in *Pritchardia*, as do the authors of the current treatment (Read and Hodel 1990).

However, as Wagner *et. al.* (1990) state, “The (*Pritchardia*) species in Hawaii are taxonomically difficult because characteristics used to distinguish species appear to be highly plastic and original descriptions were based on inadequate or poor quality specimens, and sometimes mistaken observations. Descriptions suffer from a lack of appreciation for ecological variation and inadequate herbarium material.” Additional taxonomic work on the genus is necessary and should be funded as part of recovery for *Pritchardia remota*.

*Pritchardia remota*, a member of the palm family (Arecaceae), is a tree 4 to 5 meters (13 to 16 feet) tall with a ringed, wavy trunk about 15 centimeters (5.9 inches) in diameter. The rather ruffled, fan-shaped leaves are about 80 centimeters (31 inches) in diameter and are somewhat waxy to pale green with a few tiny scales on the lower surface. The flowering stalks, up to 30 centimeters (12 inches) long, are branched and have flowers arranged spirally along the hairless stalks. Below each flower is a bract 2 to 3 millimeters (0.08 to 0.1 inch)

long. The flower consists of a cup-shaped, three-lobed calyx (fused sepals); three petals, each about 6 millimeters (0.2 inch) long; six stamens; and a three-lobed stigma. The pale greenish brown fruit is almost globose, 1.9 to 2 centimeters (0.7 to 0.8 inch) long and about 1.9 centimeters (0.7 inch) in diameter. It is the only species of *Pritchardia* on Nihoa and can be distinguished from other species of the genus in Hawaii by its wavy leaves; its short, hairless inflorescences; and its small, globose fruits (Beccari and Rock 1921, Read and Hodel 1990).

b. Life History

*Pritchardia remota* is a long-lived perennial, and populations have remained stable for several years. Conant (1985) reported finding plants with fruit and flowers in the spring and summer. Phenology may vary somewhat from year to year, depending on rainfall and climatic factors. The means of pollination are unknown, although a variety of insects have been observed visiting the flowers (D. Hopper, personal communication 1997).

c. Habitat Description

Most of the populations of *Pritchardia remota* are located in scattered, small groves in two valleys. A few trees also grow at the bases of basaltic cliffs on the steep outer slopes of each of the two valleys. Plants grow from 15 to 151 meters (50 to 500 feet) in elevation. *Pritchardia remota* is unusual among Hawaiian members of the genus in that it occurs in the relatively dry climate found on Nihoa. However, its distribution on Nihoa may be related to water availability since many plants are found in valleys and near freshwater seeps by cliffs (Rowland, personal communication 1997). Fossil loulu stems have been found near sea level on Oahu, which may indicate that the genus was more widespread before lowland habitat was altered for human use (Carlquist 1980, Cuddihy and Stone 1990). Within the Loulu Coastal Forest Community, *Pritchardia remota* assumes complete dominance with a closed canopy and thick layers of fallen fronds in the understory (Gagne and Cuddihy 1990). Native plants growing nearby include *Chenopodium oahuense*, *Sesbania tomentosa*, *Solanum nelsonii*, and *Sida fallax*. Lichens grow on the trunks of the trees (S. Conant, personal communication 1991; Derral Herbst, formerly with the U.S. Army Corps

of Engineers, personal communication 1991). *Pritchardia remota* provides nesting and other habitat for red-footed boobies (*Sula sula rubripes*) as well as occasional perching space for brown noddies (*Anous stolidus pileatus*), two of the resident seabirds on Nihoa (Conant 1985).

d. Historic and Current Ranges and Population Status

*Pritchardia remota* is known from four colonies presently extant along 0.2 kilometer (0.1 mile) of the length of each of two valleys which are about 0.6 kilometer (0.4 mile) apart on opposite sides of Nihoa. Including seedlings, 680 plants are found in scattered groups: 387 plants in West Palm Valley and 293 in East Palm Valley (Herbst 1977). Earlier totals were somewhat smaller, probably because younger seedlings were not counted (Herbst 1977). Five uncollected palms, no longer extant, were observed growing on Laysan Island in 1859 and may have been this species (Ely and Clapp 1973, Rock 1913).

e. Reasons for Decline and Current Threats

Although numbers appear to be fairly stable, this species may have experienced a reduction in total numbers due to disturbances resulting from Polynesian settlement of Nihoa. Alien plant and insect species on the island may be posing threats. Rodent predation could prove disastrous for *Pritchardia remota*, since predation of seeds by rodents has reduced the reproductive capacity of other Hawaiian *Pritchardia* species (Center for Plant Conservation (CPC) 1990b, Cuddihy and Stone 1990). Research by Male and Loeffler (1997) indicates that many species of insects, mostly aliens, feed on the seeds and fruit of several species of *Pritchardia* in the main Hawaiian Islands. Due to the small numbers of populations and individuals and its limited distribution, this species is threatened by stochastic extinction and/or reduced reproductive vigor. Flash floods, fire and human disturbances also pose potential threats.

f. Conservation Measures

*Pritchardia remota* is in cultivation in several botanical gardens. Several mature plants are in cultivation, but seeds are not banked because they do not



remain viable in storage. However, because some of these plants are descended from lineages grown *ex situ* for one or more generations, the genetic make-up of their offspring may differ from Nihoa populations due to different selective pressures. *Ex situ* propagation is possible, but must be done very carefully to prevent cross-pollination with other members of the genus.

g. Needed Recovery Actions

Immediate recovery actions should include collection of additional seeds for additional research into long-term seed storage techniques and establishment of additional *ex situ* populations. An assessment of the feasibility of introducing this palm to Laysan Island should be undertaken and, if deemed advisable, the Service should proceed with attempts to establish one or more populations on that island.

**3. *Schiedea verticillata***

**(No common name) Recovery Priority Number 2**

(Recovery Priority Number system is described in Appendix D)

a. Description and Taxonomy

The first specimens of *Schiedea verticillata* were collected near Derby's Landing in 1923. Brown (in Christophersen and Caum 1931) chose the specific epithet to refer to the verticillate (whorled) arrangement of the leaves. Although Sherff (1944) transferred the species to the genus *Alsinidendron*, current workers (Wagner *et al.* 1990) consider it to be a species of *Schiedea*.

*Schiedea verticillata*, a member of the pink family (Caryophyllaceae), is a perennial herb which dies back to an enlarged root during dry seasons (see Appendix B for line drawing). The stems, which can reach 0.4 to 0.6 meter (1.3 to 2 feet) in length, are upright or sometimes pendent (hanging). The stalkless leaves are fleshy, broad, and pale green; are usually arranged in threes; and measure 9 to 15 centimeters (3.5 to 5.9 inches) long and 7 to 9 centimeters (2.8 to 3.5 inches) wide. Flowers are arranged in open, branched clusters, usually 17 to 25 centimeters (6.7 to 9.8 inches) long. Opposite or whorled pale green bracts,

located at inflorescence branches and underneath the flowers, measure 6 to 40 millimeters (0.2 to 1.6 inches) long at the central branch and 3.5 to 6 millimeters (0.1 to 0.2 inch) long on the side branches and underneath the flowers. Each petalless flower is positioned on a stalk 5 to 20 millimeters (0.2 to 0.8 inch) long and has 5 lance-shaped sepals 8 to 10 millimeters (0.3 to 0.4 inch) long, 5 nectaries, 10 stamens, and 4 or 5 styles. The ovoid (egg-shaped) capsule measures 7 to 9 millimeters (0.3 to 0.4 inch) long and releases reddish to grayish brown seeds, about 0.7 to 0.8 millimeter (0.03 inch) long. This species, the only member of its genus to grow in the NWHI, is distinguished from other species of the genus by its exceptionally large sepals and, usually, three leaves per node (Wagner *et al.* 1990). Weller (UC Irvine, personal communication 1997) found that *Schiedea verticillata* produces more seeds and more nectar than any other species in its genus. It also has the highest degree of genetic diversity between individuals of any species in the genus.

b. Life History

*Schiedea verticillata* is a short-lived perennial. Conant's data (1985) indicated that the reproductive cycle may not be seasonal, since many life stages were found simultaneously throughout the year. Her observations also indicated that the plants flower, set, and disperse seed in a relatively short period of time. The means of pollination are unknown.

c. Habitat Description

*Schiedea verticillata* typically grows in soil pockets and cracks on coastal cliff faces at elevations between 30 and 242 meters (100 and 800 feet). Associated taxa include *Tribulus cistoides*, *Eragrostis variabilis*, *Rumex albescens*, and lichens on surrounding rock.

d. Historic and Current Ranges and Population Status

All historically known colonies of *Schiedea verticillata* are known to be extant. Colony locations and levels appear to have shifted somewhat, but total numbers have remained relatively stable for several years. Six populations,

containing a total of 385 to 414 individuals were counted between 1980 and 1983 (Conant 1985). In 1992, Service refuge staff counted only 170 to 190 plants in all six populations (K. McDermond and E. Flint, *in litt.*, 1993). However, in 1996, Rowland (1997) counted a total of 359 plants in 10 populations. These were distributed primarily on the western half of the island, although a population of 13 plants was seen on the east spur of the island near Tunnel Cave. Two previously unobserved populations containing 2 and 99 plants, respectively, were seen on the north cliffs above Miller's Valley. Other locations included a population of 24 plants at Dog's Head; 37 plants at Devil's Slide; 10 plants near Miller's Peak; a previously unknown population of 62 plants on the ridge separating West and West Palm Valleys; 80 plants near lower West Valley; 28 individuals near Pinnacle Peak, and a small colony of 4 northeast of Pinnacle Peak.

e. Reasons for Decline and Current Threats

Although numbers appear to be stable, this species may have experienced a reduction in total numbers due to disturbances resulting from Polynesian settlement of Nihoa. Alien plant and insect species on the island may be posing threats. Rodent predation could prove disastrous for *Schiedea verticillata*, since rodents may be attracted to feed on its fleshy root. It is also threatened by stochastic extinction and/or reduced reproductive vigor due to its very restricted range, small numbers, and the vulnerability of plants to disturbance events in their steep, rocky habitat (Conant 1985). Fire and other human disturbances also pose potential threats.

f. Conservation Measures

Waimea Arboretum has six plants, all propagated as cuttings from a single parent plant. NTBG has 250 seeds in storage but none in cultivation. Dr. Weller of the University of California at Irvine currently has nine plants in cultivation. Cultivation of this species has been hampered in the past by die-offs of seedlings (termed "damping off") due to a fungal disease. However, this problem can probably be controlled by using sterile soil and maintaining cool, low humidity conditions during and after germination (K. Woolliams, personal communication 1997).

g. Needed Recovery Actions

Immediate recovery actions should include collection of seeds and/or cuttings to establish additional *ex situ* populations. If research indicates that it is feasible and desirable to introduce this taxon outside of its historic range, Necker Island should be considered since it is adjacent to Nihoa, has similar habitat, and is protected as a Service refuge. Kilauea Point and Midway Atoll National Wildlife Refuges should also be assessed for suitability since they are protected areas, have plant nursery facilities, and have full-time staff. Midway has a similar climate to Nihoa and Kilauea Point has north-facing cliffs similar to Nihoa.

## RECOVERY

### A. Objectives

The objectives of the actions proposed by this recovery plan are to delist the three Nihoa taxa addressed in this plan.

The numbers of colonies and individuals given in the objectives below should provide for the maintenance of genetic diversity and provide some assurance that a single catastrophic event will not cause extinction of an entire taxon. In this plan, a colony is defined as a geographically distinct group of individuals of the same taxon that is believed to exchange genetic material with other groups in the same population. The criteria in this section are tentative due to our limited knowledge about the life history and ecology of the species. The criteria were formulated based on recommendations from the Hawaii and Pacific Plant Recovery Coordinating Committee for recovering threatened and endangered plants in general, and the advice of various experts.

These numbers may change as more is learned about the life history and after population modeling is conducted. This recovery plan should be revised in the future as new information is gathered. For example, it is unclear whether all plants of any one taxon on Nihoa constitute one population or several. Additional research needs to focus on this question.

### Interim Objectives

At least three colonies of *Amaranthus brownii* should be documented on Nihoa. Each of these colonies must be naturally reproducing with a minimum of 100 mature individuals per colony (minimum total of 300 mature plants). Mature individuals are defined as those either known or believed to be capable of reproduction. Colonies of *Pritchardia remota* and *Schiedea verticillata* are apparently stable. A monitoring program should be established to monitor their status and threats twice annually. The major threats to all three taxa must also be determined and controlled, and all three taxa must be fully represented in *ex situ* collections. *Ex situ* collections should maintain the maximum number of genetically distinct individuals practical.

### Downlisting Objectives

Interim objectives must have been attained. A total of at least five colonies of each taxon should exist on Nihoa and successful propagation and outplanting *ex situ* must be underway for each taxon. Each of these must be stable, secure, and naturally reproducing. Colony sizes on Nihoa should be increased with caution, and only if there is good evidence that Nihoa can support additional colony growth without negative ecological impacts. This is a concern because of Nihoa's small size and its relatively intact, native ecosystem. Colony sizes will ultimately be determined by the carrying capacity of the site where they are grown.

However, a preliminary target level is a minimum of 100 mature individuals per colony for *Pritchardia remota*, a minimum of 300 mature individuals per colony for *Schiedea verticillata*, and a minimum of 500 mature individuals per colony for *Amaranthus brownii*. Each colony should be stable or increasing for a minimum of 5 consecutive years before downlisting is considered. The need for continued species-specific management actions should not preclude downlisting.

As a component of threat control, a remote monitoring system should be installed on Nihoa to detect and record illegal landings and ship wrecks on the island and relay the information to Refuge staff in Honolulu.

### Delisting Objectives

Downlisting objectives must have been obtained. Delisting for any of these three taxa may require the establishment of one to three additional colonies on an island other than Nihoa. In the case of *Pritchardia remota*, Laysan Island should be considered, since a palm that may have been this species formerly occurred there. Laysan is also a Service refuge, was historically stripped of most of its native vegetation by rabbits, and is the focus of a Service ecosystem restoration planning effort. For *Schiedea verticillata* and *Amaranthus brownii*, Necker Island should be considered since it is adjacent to Nihoa, has similar habitat, and is protected as a Service refuge. Kilauea Point and Midway Atoll National Wildlife Refuges should also be assessed for suitability since they are protected areas, have plant nursery facilities, and have a full time staff. Midway has a climate similar to Nihoa and Kilauea Point also has north-facing cliffs similar to those on Nihoa.

Should establishment of one to three colonies of any or all of these taxa on an island other than Nihoa occur, delisting may be considered when they have reached the same targets as those described for downlisting. These targets are: a minimum of 100 mature individuals per colony for *Pritchardia remota*, a minimum of 300 mature individuals per colony for *Schiedea verticillata*, and a minimum of 500 mature individuals for *Amaranthus brownii*. Each colony should be stable or increasing for a minimum of 5 consecutive years.

If the establishment of any or all of these taxa on a second island proves unfeasible, delisting may be considered if the downlisting objectives have been met and the colonies persist at these levels for a minimum of 10 years.

In order to initiate delisting in any of the above situations, there should no longer be a need for continued species-specific management actions, but delisting may proceed if there is a continuing need for ecosystem-wide management actions.

## **B. Stepdown Outline**

1. Protect habitat and control threats.
  11. Develop and maintain a monitoring program.
  12. Identify and control threats for all taxa.
    121. Continue to restrict human access
    122. Maintain genetic stock *ex situ*.
    123. Control alien plants.
    124. Control alien insects, if they pose a threat.
    125. Prevent introduction of new alien species to Nihoa.
      1251. Continue regular surveys for aliens on Nihoa.

1252. Install and maintain remote monitors.
  126. Monitor for rodents and control, if necessary.
  127. Monitor for disease and control, if necessary.
  128. Ensure availability of pollination vectors, if necessary.
  129. Control other threats, as necessary.
2. Conduct essential research.
    21. Collect diagnostic data on crucial associated ecosystem components and map alien vegetation.
    22. Study various aspects of growth.
    23. Study reproductive viability.
    24. Determine parameters of viable populations.
    25. Determine the kind and degree of threat posed by selected introduced organisms and diseases.
    26. Determine effective control methods to combat threats found by completing task 25.
    27. Develop long-term seed storage, propagation, and outplanting techniques.
    28. Research and clarify taxonomy of *Pritchardia* genus.
    29. Evaluate research results and use in future management.
  3. Increase numbers and locations of *Amaranthus brownii*.



31. Augment existing colonies.
32. Reestablish colonies within historic locations on Nihoa.
4. Reestablish *Pritchardia remota* on Laysan Island.
  41. Assess suitability and feasibility of reintroduction.
  42. Prepare sites.
  43. Outplant and monitor.
  44. Control threats.
5. Evaluate potential for establishing taxa outside their historic ranges.
  51. Investigate feasibility and desirability of introduction.
  52. Identify specific introduction sites on other Hawaiian Islands.
  53. Protect and prepare establishment sites and plant.
  54. Monitor and maintain new populations.
6. Validate and revise recovery objectives.
  61. Determine the number of populations needed for long term survival.
  62. Determine the number of individuals needed for long term survival.
  63. Refine/revise downlisting and delisting criteria.

## **C. Stepdown Narrative**

### **1. Protect habitat and control threats.**

Given the precariously low numbers and limited range of the Nihoa plants, and the severity of current and potential threats, the highest priority actions must be aimed at protecting all extant wild individuals and populations, managing habitat to enhance survival, and ensuring maintenance of adequate genetic stock *ex situ*.

#### **11. Develop and maintain a monitoring program.**

Currently, Service staff are able to visit Nihoa Island only once a year, at the most. That does not provide sufficient time for assessment of the health and stability of the populations of the three Nihoa taxa. It also may not be sufficient for identification and control of threats to these and other taxa on the island. It is recommended that the Service conduct at least two monitoring trips per year. One trip should be in the winter, when *Amaranthus brownii* are most likely to be present and bearing seed. Winter surveys have not been conducted since 1983.

Existing populations of the Nihoa taxa should be monitored to ensure that current information is available regarding the status of each taxon. A detailed monitoring plan should be designed and implemented for each of the taxa. Permanent plots should be set up and mapped in order to establish baseline information regarding population size and local distribution patterns as well as the occurrence of other species in the vicinity. Individual plants may also be carefully tagged as appropriate for monitoring purposes. Data collection should include quantities and locations of all extant plants as well as any other relevant observations regarding habitat or situation. Plots should be set up to allow point- and/or line-intercept monitoring methods as appropriate for each situation. Information such as changes in numbers of plants by size class, changes in vigor of individual plants, results of management activities, and changes or disturbances to the environment should be noted as appropriate and that data recorded.

#### **12. Identify and control threats for all taxa.**

Management of protected areas to reduce and/or eliminate threats to the Nihoa plants is essential to the survival and recovery of these taxa.

121. Continue to restrict human access.

Refuge staff should continue to monitor and restrict human access to Nihoa in order to minimize habitat damage and introduction of aliens.

122. Maintain genetic stock *ex situ*.

Cultivated populations of each Nihoa plant taxon should be maintained in order to establish pools of genetic resources for reintroduction to appropriate sites and to safeguard against loss of these species due to catastrophic events. However, cultivation of these plants is not a substitute for their preservation in the wild.

As broad a complement as possible of the existing genetic stock for each taxon should be preserved. For each identifiable population (either from extant sites or traceable, pure, cultivated material), genetic material from as many individuals as feasible should be collected. Collection methods and quantities of materials collected should be devised so as to have minimal impact on wild populations. All collected materials should be labeled accurately as to exact origin, collection date, etc. Seeds collected for long-term storage should be tested for viability when first collected for baseline comparison and periodically retested and recollected as necessary.

123. Control alien plants.

Pigweed, the best established alien plant, should be controlled, especially in the vicinity of the endangered plant taxa. The full scope of alien plant control activities will be determined based on the results of research task 25. Research task 26 will identify the most effective means of alien plant control. Alien plants are a major threat to native plants throughout the Hawaiian Islands and should be dealt with promptly on Nihoa.

However, it is important to realize that habitat disturbance by weed removal activities can be highly detrimental to native ecosystems. Steps should always be taken to avoid both direct and indirect damage to the environment. Potential damage can include trampling of endangered taxa and the introduction of alien plant seeds.

124. Control alien insects, if they pose a threat.

Over 70 alien insect species have already been identified on Nihoa. If research task 25 indicates that any of these pose a threat to Nihoa plant taxa, alien insect control should be given a high priority. However, if biocontrol agents are considered, proposed biocontrol agents must be subjected to extremely thorough testing to insure that they would not negatively affect native flora or fauna.

125. Prevent introduction of new alien species to Nihoa.

Introductions of new alien species need to be halted to prevent additional new threats to the Nihoa taxa and their habitats. Human activities are the primary preventable cause of new introductions and must be closely controlled.

1251. Continue regular surveys for aliens on Nihoa.

During the twice yearly monitoring trips, surveys for alien species of plants and insects should be conducted to document and control the introduction and spread of alien species harmful to the Nihoa taxa.

1252. Install and maintain remote monitors.

A remote monitoring system should be installed to detect and record illegal boat landings and ship wrecks. Ideally, a satellite link will relay live images to Refuge staff in Honolulu. This would allow Refuge staff to respond quickly to threats. A cheaper but less effective alternative would be to have remote cameras record still shots of trespassers and vessels. The film would be periodically retrieved when Service employees visit the island. Illegal landings pose a serious risk of introducing rodents and other alien species, as well as fire, unauthorized collection of plants, and other habitat disturbances.

126. Monitor for rodents and control, if necessary.

Due to the constant risk of illegal landings or shipwrecks, Nihoa should be regularly monitored for rodents. Baited traps could be set and checked periodically. If rodents are found, an aggressive eradication program should be implemented immediately. Application of rodenticides is likely the most effective means of removing rodents

from Nihoa, and would involve follow-up monitoring to insure that all animals had been removed. Planning and preparation for rodent eradication should be done in advance to allow the rapid and effective implementation of an eradication program. Planning should cover the type and amount of rodenticide needed, sources for purchasing rodenticides and equipment, type and location of bait stations, logistics of application, follow-up monitoring, and obtaining any necessary regulatory permits in advance.

127. Monitor for disease and control, if necessary.

If the results of task 25 show that disease is a threat to any of the Nihoa taxa, then control measures should be devised and implemented.

128. Ensure availability of pollination vectors, if necessary.

Based on the results of research task 23, steps should be taken to ensure that pollination vectors remain available to the Nihoa plant taxa. If it is discovered that pollination vectors for certain taxa are missing, necessary measures should be taken to compensate for these.

129. Control other threats, as necessary.

The need for control of other threats may become apparent as more is learned about the Nihoa taxa. As new threats arise, management actions to reduce and/or eliminate their effects on the Nihoa taxa should be implemented.

2. Conduct essential research.

Research into various aspects of the life history, habitat, pollinators, reproductive biology, symbionts (organisms benefitting from a mutual relationship), optimum requirements for growth, techniques for seed storage and propagation, requirements for population viability, and control of threats to each of the Nihoa taxa must be carried out to better understand the requirements necessary for perpetuation of these plants. Research must also determine whether the discrete groups of plant taxa are really distinct populations and clarify the taxonomy of the *Pritchardia* genus. This knowledge will allow more appropriate management and assessment techniques to be developed, and is needed in order to determine meaningful parameters for definition of specific recovery criteria for each taxon.

21. Collect diagnostic data on crucial associated ecosystem components and map alien vegetation.

Composition of flora and invertebrate, bird, and other fauna populations should be established to attempt to gain an understanding of the relationships between these organisms and the Nihoa plants and to provide habitat in which these taxa may survive and reproduce without constant species-specific management. Collecting soil cores for pollen analysis on Nihoa would be particularly valuable for re-constructing the botanical history of the island and assessing changes over time due to alien species and human impacts.

Periodic mapping of alien vegetation is recommended using various techniques, including direct ground observations as well as aerial color and/or infrared photographs in order to compare to previous maps and photos and determine overall changes in alien vegetation patterns where the Nihoa plants occur. Such mapping would allow changes in distributions and abundance of alien plants to be followed so that appropriate management actions may be taken.

22. Study various aspects of growth.

Various aspects of the growth of each taxon need to be studied, including: growth and mortality of seedlings; growth of mature plants, including seasonal changes; optimum conditions and limiting factors; seasonal differences in temperature and light needs; water sources and requirements; and soil and nutrient requirements.

23. Study reproductive viability.

Factors affecting the reproductive viability of each of the Nihoa taxa need to be determined, including: breeding systems, including self-compatibility; pollination vectors; and preferred conditions for flowering and seed set. This information will allow the best management strategy for each taxon to be developed. Studies of pollination vectors are especially important if populations are to be established on other islands, since the populations may not be self-sustaining unless the proper pollinating species are present.

24. Determine parameters of viable populations.

Parameters of viable populations need to be established. Such information could be used to more precisely determine parameters for

consideration of downlisting or delisting. These parameters include: minimum numbers of individuals and populations needed for long-term survival; demographics; longevity; minimum range needed for long-term survival; genetic relationships and susceptibility to inbreeding depression; and dispersal potential. This work should also determine how many actual, non-interbreeding populations of each taxa are present on Nihoa.

25. Determine the kind and degree of threat posed by selected introduced organisms and diseases.

The effects of introduced organisms, including plants, harmful insects and disease on the Nihoa taxa need to be determined in order to better manage the endangered plants and their habitats.

26. Determine effective control methods to combat threats found by completing task 25.

Effective control methods to combat rodents, diseases, and insects which may adversely affect the Nihoa taxa need to be developed, ensuring that control measures do not adversely affect components of the native ecosystem.

27. Develop long-term seed storage, propagation, and outplanting techniques.

This task is important for all the taxa in this plan but is especially critical for the *Amaranthus brownii*, due to its low numbers and decreasing numbers. Micropropagation of tissues and/or seeds may be the only means of creating enough plants of this species to establish viable *ex situ* and wild populations. *Pritchardia* seeds do not store well and additional research into long-term seed storage techniques, such as cryopreservation, needs to be conducted. Research on *Schiedea verticillata* is recommended to determine how to prevent seedling mortality caused by fungal infection. Outplanting techniques need to be investigated for all taxa. In addition to botanical gardens, use of existing plant propagation staff and facilities at Kilauea Point and Midway Atoll National Wildlife Refuges should be considered. Transporting soil between islands should be avoided.

28. Research and clarify taxonomy of *Pritchardia* genus.

Research is needed to clarify the taxonomic confusion surrounding the *Pritchardia* genus. This information will help determine suitability of outplanting sites on other islands.

29. Evaluate results and use in future management.

The results of the above studies should be evaluated and incorporated into the management process and development of scientifically credible recovery targets.

3. Increase numbers and locations of *Amaranthus brownii* on Nihoa.

Once propagation techniques have proven successful, steps should be taken to increase the numbers of this herbaceous annual on Nihoa. Careful records and monitoring of all activities should be maintained to provide data and guidance for future efforts.

31. Augment existing colonies.

The size of existing colonies on Nihoa should be increased via outplanting and/or eliminating factors restricting colony expansion (*e.g.*, competition from alien species). Progress should be monitored.

32. Reestablish colonies within historic locations on Nihoa.

Colonies should be reestablished on Miller's Ridge and ridges to the east via outplanting and/or eliminating factors restricting colony expansion (*e.g.*, competition from alien species). Progress should be monitored.

4. Reestablish *Pritchardia remota* on Laysan Island.

This recovery action involves re-establishing *Pritchardia remota* on Laysan Island, where it is believed to have occurred in the past. The goal of reintroduction is to permanently reestablish viable populations of this taxon in stable and secure conditions. Such reintroduction should be recommended conservatively and only after careful consideration of potential consequences. Genetic purity of populations is a prime concern, as are habitat carrying capacity, documentation of artificially established populations, and the possibility of introducing pathogens to natural areas. Reintroduction efforts should always be well-documented as to lineage and monitored closely.

41. Assess suitability and feasibility of reintroduction.

Research on ecological effects of reintroducing *Pritchardia remota* on Laysan needs to be completed. Carrying capacities of the limited habitats and impacts on other native flora and fauna should be assessed.



42. Prepare sites.

Sites should be prepared for planting and immediate threats eliminated, such as alien weeds.

43. Outplant and monitor.

After site preparation, the selected material should then be planted. Selected materials should be free from pests, diseases, and pathogens which might be introduced to other native taxa. This aspect is particularly critical since cultivated plants may have been grown in the presence of other pathogen-carrying plants, and wild populations may have lower resistance to such introductions. Frequent monitoring will be required to correct any problems and collect data for future outplanting efforts.

44. Control threats.

Sites must be protected appropriately, including alien species control. Frequent monitoring is needed to identify and control any threats before they become serious.

5. Evaluate potential for establishing taxa outside their historical ranges.

To protect the taxa from catastrophic events and achieve recovery objectives, it may be necessary to establish one to three colonies of each taxa on islands outside their historic range. Extensive research into the ecology and propagation of these taxa will be required prior to implementing any of these actions. Efforts should be monitored closely.

51. Investigate feasibility and desirability of introduction.

Extensive research on ecological effects of establishing the Nihoa taxa outside of their historical range will need to be completed before such establishments are considered. Impacts on native flora and fauna at transplant sites will need to be assessed, and the potential for hybridization with closely related species will also have to be considered.

52. Identify specific introduction sites on other Hawaiian Islands.

Establishment sites on other Hawaiian Islands should be identified. This will be an involved process requiring considerable research and coordination with experts. Factors to consider include: avoiding negative impacts to native species at establishment sites, finding habitats suitable for

the Nihoa taxa, and choosing areas accessible enough to allow for planting and monitoring of introduced populations. Necker, Midway, Laysan, and Kauai should all be considered as potential sites. Necker Island should be considered since it is adjacent to Nihoa, has similar climate and habitat, and is protected as a Service refuge. Laysan is also part of the Refuge system, was historically stripped of most of its native vegetation by rabbits, and is the focus of a Service ecosystem restoration planning effort. Kilauea Point and Midway Atoll National Wildlife Refuges should also be assessed for suitability since they are protected areas, have plant nursery facilities, and have full-time staff. Kilauea Point also has north-facing cliffs similar to those on Nihoa.

53. Protect and prepare establishment sites and plant.

Selected sites must be prepared and protected appropriately, including alien species control. The selected material should then be planted. Selected materials should be free from pests, diseases, and pathogens that might be introduced to the new or nearby wild populations. This is critical since cultivated plants may have been grown in the presence of other pathogen-carrying plants, and wild populations may have lower resistance to such introductions.

54. Monitor and maintain new populations.

Newly established populations should be monitored carefully. Monitoring should be geared to detect any negative effects of introducing the taxa outside their historic range. Ongoing maintenance of each site should occur after initial preparation and planting. The same protection and procedures recommended for existing sites should also apply to new sites.

6. Validate and revise recovery objectives.

The scientific validity of the recovery objectives should be reviewed as more information becomes available.

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

For each of the Nihoa taxa, a determination of the number of populations needed for long-term survival should be made.

62. Determine the number of individuals needed for long term survival.

The number of individuals needed in each population to ensure the long-term maintenance of genetic diversity must be determined for each taxon.

63. Refine/revise downlisting and delisting criteria.

Based on scientific information gathered during recovery efforts (*e.g.*, data on viable population sizes, longevity, etc.), recovery criteria for each of the Nihoa plant taxa should be revised to reflect new information. Until such time as additional sound information is available, the criteria presented in this recovery plan should be used as the bases for downlisting and delisting.

## LITERATURE CITED

- Beardsley, J.W. 1966. Insects and other terrestrial arthropods from the Leeward Hawaiian Islands. *Proceedings, Hawaiian Entomological Society* 19:157-185.
- Beccari, O. 1890. Le palme del genere Pritchardia. *Malesia* 3:281-317.
- Beccari, O., and J.F. Rock. 1921. A monographic study of the genus Pritchardia. *Mem. Bernice P. Bishop Mus.* 8:1-77.
- Bryan, E.H., Jr. 1978. The Northwestern Hawaiian Islands; an annotated bibliography. U.S. Fish and Wildlife Service, Honolulu, 190 pp.
- Carlquist, S. 1980. Hawaii, a natural history. Geology, climate, native flora and fauna above the shoreline. Second edition. Pacific Tropical Botanical Garden, Lawai, Hawaii, 468 pp.
- Center for Plant Conservation. 1990a. Hawaiian priority A plants (103 records) as of 26 MAR 1990. Unpubl. report. Jamaica Plain, Massachusetts.
- Center for Plant Conservation. 1990b. Hawaiian priority [A] and [B] plants as of 18 DEC 1990. Unpubl. report. Jamaica Plain, Massachusetts.
- Christophersen, E., and E.L. Caum. 1931. Vascular plants of the Leeward Islands, Hawaii. *Bernice P. Bishop Mus. Bull.* 81:1-41.
- Clapp, R.B., E. Kridler, and R.R. Fleet. 1977. The natural history of Nihoa Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 207:1-147.
- Cleghorn, P.L. 1987. Prehistoric cultural resources and management plan for Nihoa and Necker Islands, Hawai'i. Unpubl. manuscript prepared for U.S. Fish and Wildlife Service, Honolulu.
- Conant, P. 1997. Entomological highlights of the July 7-July 27, 1996 Nihoa

- expedition. Unpublished report. Hawaii Department of Agriculture.
- Conant, S. 1983a. An analysis and compilation of habitat types on Necker and Nihoa Islands, Hawaiian Islands National Wildlife Refuge, as they relate to the feasibility of establishing the Nihoa millerbird on Necker Island. Unpubl. report prepared for Office of Endangered Species, U.S. Fish and Wildlife Service, Honolulu, 21 pp.
- Conant, S. 1983b. Ecological requirements of the Nihoa millerbird and the Nihoa finch, including an analysis of management options for the millerbird. Unpubl. report prepared for Office of Endangered Species, U.S. Fish and Wildlife Service, Honolulu, 47 pp.
- Conant, S. 1985. Recent observations on the plants of Nihoa Island, Northwestern Hawaiian Islands. *Pacific Sci.* 39:135-149.
- Conant, S., C. Christensen, P. Conant, W.C. Gagne, and M.L. Goff. 1984. The unique terrestrial biota of the Northwestern Hawaiian Islands: in Grigg, R.W., and K.Y. Tanoue (eds.), *Resource investigations in the Northwestern Hawaiian Islands*. Vol. 1. University of Hawaii Sea Grant Coll. Program (UNIHI-SEAGRANT-MR-84-01), Honolulu, pp. 77-94.
- Conant, S., and D. Herbst. 1983. A record of *Nephrolepis multiflora* from Nihoa Island, Northwestern Hawaiian Islands. *Newsl. Hawaiian Botanical Soc.* 22:17-19.
- Cuddihy, L.W., and C.P. Stone. 1990. Alteration of native Hawaiian vegetation; effects of humans, their activities and introductions. *Coop. Natl. Park Resources Stud. Unit, University of Hawaii, Honolulu*, 138 pp.
- Culliney, J.L. 1988. *Islands in a far sea; nature and man in Hawaii*. Sierra Club Books, San Francisco, 410 pp. Department of Geography, University of Hawaii. 1983. *Atlas of Hawaii*. Second edition. University of Hawaii Press, Honolulu, 238 pp.

Department of the Interior, U.S. Fish and Wildlife Service, Region One. 1986a. Hawaiian Islands National Wildlife Refuge, County of Honolulu; Final master plan/environmental impact statement. U.S. Fish and Wildlife Service, Honolulu.

Department of the Interior, U.S. Fish and Wildlife Service, Region One. 1986b. Hawaiian Islands National Wildlife Refuge; Master plan/environmental impact statement; technical appendices. U.S. Fish and Wildlife Service, Honolulu.

Department of the Interior, U.S. Fish and Wildlife Service, Region One. 1996. Endangered and threatened wildlife and plants; endangered status for three plants from the Island of Nihoa, Hawaii. Federal Register 61(163):43178-43184. August 21, 1996.

Ely, C.A., and R.B. Clapp. 1973. The natural history of Laysan Island, Northwestern Hawaiian Islands. Atoll Res. Bull. 171:1-361.

Emory, K.P. 1928. Archaeology of Nihoa and Necker islands. Bernice P. Bishop Mus. Bull. 53:1-124.

Gagne, W.C. 1982. Working towards an assessment of the conservation status of Hawaii's endemic arthropods, with emphasis on the moths or Lepidoptera. Proc. 4th Conf. in Nat. Sci., Hawaii Volcanoes National Park, pp. 63-72.

Gagne, W.C., and S. Conant. 1983. Nihoa: biological gem of the Northwest Hawaiian Islands. Ka 'Elele 10(7):3-5.

Gagne, W.C., and L.W. Cuddihy. 1990. Vegetation: in Wagner, W.L., D.R. Herbst, and S.H. Sohmer, Manual of the flowering plants of Hawai'i. University of Hawaii Press and Bishop Museum Press, Honolulu. Bishop Mus. Spec. Publ. 83:45-114.

Harrison, C.S. 1990. Seabirds of Hawaii; natural history and conservation.

Cornell University Press, Ithaca, NY, 249 pp.

Hawaii Heritage Program. 1990a1. Element Occurrence Record for Amaranthus brownii, PDAMA04090.001, dated July 16, 1990, Honolulu. Unpubl., 2 pp.

Hawaii Heritage Program. 1990a2. Element Occurrence Record for Amaranthus brownii, PDAMA04090.002, dated July 16, 1990, Honolulu. Unpubl., 2 pp.

Hawaii Heritage Program. 1990b1. Element Occurrence Record for Schiedea verticillata, PDCAR0R0S0.001, dated July 13, 1990, Honolulu. Unpubl., 1 p.

Hawaii Heritage Program. 1990b2. Element Occurrence Record for Schiedea verticillata, PDCAR0R0S0.003, dated July 13, 1990, Honolulu. Unpubl., 1 p.

Hawaii Heritage Program. 1990b3. Element Occurrence Record for Schiedea verticillata, PDCAR0R0S0.004, dated May 19, 1990, Honolulu. Unpubl., 2 pp.

Hawaii Heritage Program. 1990b4. Element Occurrence Record for Schiedea verticillata, PDCAR0R0S0.005, dated July 6, 1990, Honolulu. Unpubl., 2 pp.

Hawaii Heritage Program. 1990b5. Element Occurrence Record for Schiedea verticillata, PDCAR0R0S0.006, dated July 6, 1990, Honolulu. Unpubl., 2 pp.

Hawaii Heritage Program. 1990b6. Element Occurrence Record for Schiedea verticillata, PDCAR0R0S0.007, dated July 13, 1990, Honolulu. Unpubl., 2 pp.

Herbst, D.R. 1977. Vegetation: in Clapp, R.B., E. Kridler, and R.R. Fleet, The natural history of Nihoa Island, Northwestern Hawaiian Islands. Atoll Res. Bull. 207:26-38.

- Herbst, D.R. 1980. Miscellaneous notes on the Hawaiian flora I. *Phytologia* 45:67-81.
- Hillebrand, W. 1888. *Flora of the Hawaiian Islands: a description of their phanerogams and vascular cryptogams*. Carl Winter, Heidelberg, Germany; Williams & Norgate, London; B. Westermann & Co., New York, 673 pp. (Facsimile ed., 1965, Hafner Publ. Co., New York, 673 pp.).
- Honolulu, Department of General Planning. 1988. *General plan; objectives and policies*. City and County of Honolulu.
- Kramer, P.J. 1962. Trip report to Nihoa Island, December 1961. U.S. Fish and Wildlife Service Administrative Report, Honolulu, 24 pp.
- Kuntze, O. 1891. *Revisio generum plantarum vascularium omnium atque cellularium multarum secundum leges nomenclaturae internationales cum enumeratione plantarum exoticarum in itinere mundi collectarum . . . vol. 2*. Arthur Felix, Leipzig.
- Kuntze, O. 1898. *Revisio generum plantarum vascularium omnium atque cellularium multarum secundum leges nomenclaturae internationales cum enumeratione plantarum exoticarum in itinere mundi collectarum . . . vol. 3*. Arthur Felix, Leipzig.
- Macdonald, G.A., A.T. Abbott, F.L. Peterson. 1983. *Volcanoes in the sea; the geology of Hawaii*. Second edition. University of Hawaii Press, Honolulu, 517 pp.
- Male, T. And W. Loeffler. 1997. Patterns of distribution and seed predation of *Pritchardia hillebrandii*. *Newsletter of the Hawaiian Botanical Society* 36(1):1-11. March 1997.
- Marshall, D.B. 1964. Treasure islands--of wildlife. *Audubon Magazine* 66:160-165.



- Miller, S.K. 1983. Socio-economic trade-offs in the development of management policies for the Northwest Hawaiian Islands. Ph.D. dissertation, University of Hawaii, Honolulu, 207 pp.
- Read, R.W., and D.R. Hodel. 1990. Arecaceae: *in* Wagner, W.L., D.R. Herbst, and S.H. Sohmer, Manual of the flowering plants of Hawai'i. University of Hawaii Press and Bishop Museum Press, Honolulu. Bishop Mus. Spec. Publ. 83:1360-1375.
- Rock, J.F. 1913. The indigenous trees of the Hawaiian Islands. Publ. privately, Honolulu, 512 pp.
- Rowland, C. 1997. Draft trip report for the July 7-July 27 Nihoa expedition. Unpublished report. U.S. Fish and Wildlife Service, Pacific Islands Office.
- Sherff, E.E. 1944. Some additions to our knowledge of the flora of the Hawaiian Islands. Amer. J. Bot. 31:151-161.
- Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1986. Contributions to the flora of Hawaii. I. Acanthaceae-Asteraceae. Bishop Mus. Occas. Pap. 26:102-122.
- Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the flowering plants of Hawai'i. University of Hawaii Press and Bishop Museum Press, Honolulu. Bishop Mus. Spec. Publ. 83:1-1853.
- Wagner, W.L., D.R. Herbst, and R.S.N. Yee. 1985. Status of the native flowering plants of the Hawaiian Islands: *in* Stone, C.P., and J.M. Scott (eds.), Hawai'i's terrestrial ecosystems: preservation and management. Coop. Natl. Park Resources Stud. Unit, University of Hawaii, Honolulu, pp. 23-74.
- Walker, G. 1990. Geology: *in* Wagner, W.L., D.R. Herbst, and S.H. Sohmer, Manual of the flowering plants of Hawai'i. University of Hawaii Press and Bishop Museum Press, Honolulu. Bishop Mus. Spec. Publ. 83:21-35.

Weller, S.G., A.K. Sakai, W.L. Wagner, and D.R. Herbst. 1990. Evolution of dioecy in Schiedea (Caryophyllaceae; Alsinoideae) in the Hawaiian Islands: biogeographical and ecological factors. *Systematic Botany* 15(2):266-276.

## IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated cost for the Nihoa plant 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 organizations involved and/or responsible for committing funds, and lastly, estimated costs. When more than one organization 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. Monetary needs for all parties involved are identified to reach this point, whenever feasible.

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:**

BOT	Various botanical gardens ( <i>e.g.</i> , Waimea Arboretum, Honolulu Botanical Gardens, National Tropical Botanical Garden, Lyon Arboretum, etc.)
BRD	Biological Resources Division of the U.S. Geological Survey, Pacific Islands Office
C	Once started, task will continue through recovery
DLNR	Hawaii Department of Land and Natural Resources
FWS	U.S. Fish and Wildlife Service, Pacific Islands Ecoregion, Honolulu, Hawaii
O	Ongoing activity
RES	Researchers from various agencies and universities
TBD	To be determined
WS	U.S. Department of Agriculture, Wildlife Services

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR NIHOA PLANT SPECIES

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Party	Total Cost Through 2012	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
1	11	Develop and maintain monitoring program	C	FWS*	450.0	30	30	30	30	30
				RES	150.0	10	10	10	10	10
1	121	Continue to restrict human access	O	FWS	30.0	2	2	2	2	2
1	122	Maintain genetic stock <i>ex situ</i>	C	BOT*	150.0	10	10	10	10	10
				FWS	150.0	10	10	10	10	10
1	123	Control alien plants	C	FWS		TBD				
1	124	Control alien insects, if they pose a threat	C	FWS		TBD				
1	1251	Continue regular surveys for aliens on Nihoa	O	FWS	225.0	15	15	15	15	15
1	1252	Install and maintain remote monitors	O	FWS	114.0	100	1	1	1	1

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR NIHOA PLANT SPECIES

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Party	Total Cost Through 2012	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
1	126	Monitor for rodents and control, if necessary	O	FWS*	15.0	TBD	1	1	1	1
				WS	15.0	TBD	1	1	1	1
1	127	Monitor for disease and control, if necessary	C	BRD*		TBD				
				FWS		TBD				
1	128	Ensure availability of pollination vectors	C	BRD*		TBD				
				FWS		TBD				
1	129	Control other threats, as necessary	TBD	FWS*		TBD				
				BRD		TBD				
NEED 1 (Protect habitat and control threats)					1,297.0	177	80	80	80	80
2	21	Collect diagnostic data on crucial ecosystem components and map alien vegetation	C	BRD*	235.0	45	45	45	45	5
				FWS	95.0	21	21	21	21	1
				RES	62.0	10	10	10	10	2

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR NIHOA PLANT SPECIES

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Party	Total Cost Through 2012	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
2	22	Study various aspects of growth	4	BRD*	80.0	20	20	20	20	
				FWS	40.0	10	10	10	10	
				RES	40.0	10	10	10	10	
2	23	Study reproductive viability	4	BRD*	80.0	20	20	20	20	
				FWS	40.0	10	10	10	10	
				RES	40.0	10	10	10	10	
2	24	Determine parameters of viable populations	4	BRD*	80.0	20	20	20	20	
				FWS	40.0	10	10	10	10	
				RES	40.0	10	10	10	10	
2	25	Determine kind and degree of threat posed by selected introduced organisms and diseases	4	BRD*		TBD				
				FWS		TBD				
				RES		TBD				

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR NIHOA PLANT SPECIES

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Party	Total Cost Through 2012	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
2	26	Determine control methods to combat threats	TBD	BRD*		TBD				
				FWS		TBD				
				RES		TBD				
2	27	Develop seed storage, propagation, and outplanting	3	BOT*	150.0	50	50	50		
				FWS	90.0	30	30	30		
				RES	90.0	30	30	30		
2	28	Research and clarify taxonomy of <i>Pritchardia</i> genus	2	RES*	40.0	20	20			
				BOT	40.0	20	20			
2	29	Evaluate results and use in future management	C	FWS*	30.0	2	2	2	2	2
NEED 2 (Conduct essential research)					1,312.0	348	348	308	198	10
2	31	Augment existing colonies of <i>Amaranthus brownii</i>	10	FWS*	80.0				15	15



RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR NIHOA PLANT SPECIES

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Party	Total Cost Through 2012	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
2	32	Reestablish colonies within historic locations on Nihoa.	10	FWS*	80.0				15	15
NEED 3 (Augment existing colonies of <i>Amaranthus brownii</i> )					160.0				30	30
2	41	Assess suitability and feasibility of reintroduction	2	FWS*	10.0	5	5			
				BRD	10.0	5	5			
				DLNR	10.0	5	5			
				RES	10.0	5	5			
2	42	Prepare sites	1	FWS	10.0			10		
2	43	Outplant and monitor	C	FWS	70.0			10	5	5
2	44	Control threats	C	FWS	26.0			2	2	2
				WS	26.0			2	2	2
NEED 4 (Reestablish <i>Pritchardia remota</i> on Laysan Island)					152.0	10	10	24	9	9

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR NIHOA PLANT SPECIES

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Party	Total Cost Through 2012	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
2	51	Investigate feasibility and desirability of introduction	3	FWS*	15.0	5	5	5		
				BRD	15.0	5	5	5		
				DLNR	15.0	5	5	5		
				RES	15.0	5	5	5		
2	52	Identify specific introduction sites on other Hawaiian islands	2	FWS*	20.0	10	10			
				DLNR	20.0	10	10			
2	53	Protect and prepare establishment sites and plant	2	FWS*	200.0				100	100
				DLNR	200.0				100	100
2	54	Monitor and maintain new populations	C	FWS*	240.0				20	20
				DLNR	240.0				20	20
NEED 5 (Explore necessity of establishing taxa outside their historic range)					980.0	40	40	20	240	240

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR NIHOA PLANT SPECIES

Priority #	Task #	Task Description	Task Duration (Years)	Responsible Party	Total Cost Through 2012	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
3	61	Determine number of populations needed for long term survival	5	FWS*	10.0	2	2	2	2	2
				BRD	10.0	2	2	2	2	2
				RES	10.0	2	2	2	2	2
3	62	Determine number of individuals needed for long-term survival	5	FWS*	10.0	2	2	2	2	2
				BRD	10.0	2	2	2	2	2
				RES	10.0	2	2	2	2	2
3	63	Refine/revise downlisting and delisting criteria	C	FWS	30.0	2	2	2	2	2
NEED 6 (Validate and revise recovery criteria)					90.0	14	14	14	14	14
TOTAL COST					3,991.0	589	492	446	571	383

## **APPENDIX A - AGENCY AND PEER REVIEWERS**

### USFWS Washington, D.C.

Chief, U.S. Fish and Wildlife Service  
Division of Endangered Species  
Arlington Square Building  
4401 N. Fairfax Dr., Room 452  
Arlington, VA 22203

Chief, Office of Public Affairs  
U.S. Fish and Wildlife Service, DOI  
Main Interior Building  
1849 C. St, NW, Room 3447  
Washington, D.C. 20240

Chief, Office of Internal Affairs  
U.S. Fish and Wildlife Service  
Washington, DC 20240

Chief, U.S. Fish and Wildlife Service  
Division of Refuges and Wildlife  
4401 N. Fairfax Dr., Rm. 670  
Arlington, VA 22203

### Others - Washington, D.C.

Biological Resources Division, U.S.G.S.  
Office of Research Support  
4401 N. Fairfax Dr., Room 725  
Arlington, VA 22203

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

Ms. Peggy Olwell  
National Park Service  
Wildlife and Vegetation  
P.O. Box 37127  
Washington, DC 20013

Dr. Warren L. Wagner  
Botany Department, NHB #166  
Smithsonian Institution  
Washington D.C. 20560

USFWS - Pacific Islands Ecoregion

Biodiversity Joint Venture Coordinator  
U.S. Fish and Wildlife Service  
P.O. Box 50088  
Honolulu, HI 96850

Marie Bruegmann (\*\*)  
U.S. Fish and Wildlife Service  
300 Ala Moana, Room 3108  
Honolulu, HI 96850

Federal Aid Coordinator  
U.S. Fish and Wildlife Service  
300 Ala Moana Blvd., Rm. 3315A  
P.O. Box 50167  
Honolulu, HI 96850

Field Supervisor, Pacific Islands Ecoregion  
Refuges and Wildlife  
U.S. Fish and Wildlife Service  
P.O. Box 50167  
Honolulu, HI 96850

Dr. Elizabeth Flint (\*\*)  
U.S. Fish and Wildlife Service  
Pacific Islands Office  
300 Ala Moana, Room 5302  
Honolulu, HI 96850

David Hopper (\*\*)  
U.S. Fish and Wildlife Service  
300 Ala Moana, Room 3108  
Honolulu, HI 96850

Dr. Chuck Monett (\*\*)  
U.S. Fish and Wildlife Service  
Pacific Islands Office  
300 Ala Moana, Room 5302  
Honolulu, HI 96850

Program Leader, Contaminants  
U.S. Fish and Wildlife Service  
Pacific Islands Ecoregion  
P.O. Box 50088  
Honolulu, HI 96850

Program Leader, Interagency  
U.S. Fish and Wildlife Service  
Pacific Islands Ecoregion  
P.O. Box 50088  
Honolulu, HI 96850

Program Leader, Listing  
U.S. Fish and Wildlife Service  
Pacific Islands Ecoregion  
P.O. Box 50088  
Honolulu, HI 96850

Program Leader, Wetlands  
U.S. Fish and Wildlife Service  
Pacific Islands Ecoregion  
P.O. Box 50088  
Honolulu, HI 96850

Karen Rosa (\*\*)(\*  
U.S. Fish and Wildlife Service  
300 Ala Moana, Room 3108  
Honolulu, HI 96850

Craig Rowland (\*\*  
U.S. Fish and Wildlife Service  
300 Ala Moana, Room 3108  
Honolulu, HI 96850

Christa Russell (\*\*)(\*  
U.S. Fish and Wildlife Service  
300 Ala Moana, Room 3108  
Honolulu, HI 96850

Senior Resident Agent  
U.S. Fish and Wildlife Service  
Division of Law Enforcement  
P.O. Box 50223  
Honolulu, HI 96850

Plant Recovery Team

Mr. Patrick Dunn  
The Nature Conservancy  
111 Washington St. SE  
P.O. Box 47016  
Olympia, WA 98504-7016

Dr. Sam Gon  
The Nature Conservancy of Hawaii  
1116 Smith Street, Suite 201  
Honolulu, HI 96817

Mr. Robert Hobdy  
Division of Forestry and Wildlife  
State Office Bldg.  
54 South High St.  
Wailuku, HI 96793

Dr. James D. Jacobi  
Biological Resources Division  
Pacific Islands Science Center  
P.O. Box 44  
Hawaii Volcanoes National Park, HI 96718

Dr. Charles Lamoureaux (\*\*)  
Lyon Arboretum  
University of Hawaii at Manoa  
3860 Manoa Rd.  
Honolulu, HI 96822-1180



Mr. Joel Lau  
The Nature Conservancy of Hawaii  
1116 Smith Street, Suite 201  
Honolulu, HI 96817

Dr. Lloyd Loope  
Biological Resources Division, USGS  
Haleakala Station  
P.O. Box 369  
Makawao, HI 96768

Dr. Loyal Mehrhoff  
U.S. Fish and Wildlife Service  
Office of Technical Support  
911 NE 11th Ave.  
Portland, OR 97232-1481

Dr. Cliff Morden (\*\*)  
Department of Botany  
University of Hawaii at Manoa  
3190 Maile Way  
Honolulu, HI 96822

Mr. Steve Perlman (\*\*)  
National Tropical Botanical Garden  
P.O. Box 340  
Lawai, HI 96765

Ms. Linda Pratt  
Biological Resources Division, USGS  
P.O. Box 52  
Hawaii Volcanoes National Park, HI 96718

Dr. Gary Ray  
Aalii Consulting Ecologists  
3759 Round Top Drive  
Honolulu, HI 96822-5043

Mr. Keith R. Woolliams (\*\*)  
Waimea Arboretum and Botanical Garden  
59-864 Kamehameha Hwy.  
Haleiwa, HI 96817

Other Federal Offices

Biological Resources Division, USGS  
Pacific Islands Ecosystems Research Center  
P.O. Box 44  
Volcano, HI 96718

Ms. Lauren Bjorkman  
Resource Conservationist  
USDA - Natural Resources Conservation Service  
P.O. Box 50004  
Honolulu, HI 96850

Ms. Mary Blevins  
U.S. Environmental Protection Agency  
75 Hawthorne Street  
H-32  
San Francisco, CA 94105

Environmental Protection Agency  
Hazard Evaluation Division -EEB  
(TS769C)  
401 M St., SW  
Washington, DC 20460

Director, Pacific Area Office  
National Park Service  
P.O. Box 50165  
Honolulu, HI 96850

Director  
Institute of Pacific Islands Forestry  
U.S. Forest Service  
1151 Punchbowl St., Rm. 323  
Honolulu, HI 96813

Dr. William J. Hoe  
USDA-APHIS-PPQ  
Terminal Box 57  
Honolulu International Airport  
Honolulu, HI 96813

State of Hawaii

Michael G. Buck, Administrator (\*)  
Division of Forestry and Wildlife  
Department of Land and Natural Resources  
1151 Punchbowl St., Room 325  
Honolulu, HI 96813

The Honorable Benjamin Cayetano  
Governor, State of Hawaii  
State Capitol  
Honolulu, HI 96813

Patrick Conant (\*\*)  
State of Hawaii Department of Agriculture  
P.O. Box 22159  
Honolulu, HI 96823-2159

Mr. Paul Conry  
Hawaii Department of Land and Natural Resources  
Division of Forestry and Wildlife  
1151 Punchbowl Street, Rm. 325  
Honolulu, HI 96813

Dr. Carolyn Corn (\*)  
Hawaii Department of Land and Natural Resources  
Division of Forestry and Wildlife  
1151 Punchbowl Street, Rm. 325  
Honolulu, HI 96813

Ms. Betsy Harrison-Gagne  
Department of Land and Natural Resources  
Natural Area Reserve System  
Kendall Building  
888 Mililani St., Suite 700  
Honolulu, HI 96813

Office of Hawaiian Affairs (\*)  
711 Kapiolani Boulevard, suite 500  
Honolulu, HI 96813

Mr. Randy Kennedy  
Department of Land and Natural Resources  
Natural Area Reserve System  
1151 Punchbowl St.  
Honolulu, HI 96813

Oahu District Manager  
Division of Forestry and Wildlife  
1151 Punchbowl St., Rm. 325  
Honolulu, HI 96813

Mr. Michael Wilson  
Chairperson  
Board of Land and Natural Resources  
1151 Punchbowl St.  
Honolulu, HI 96813

Libraries

Hawaii State Library  
478 South King Street  
Honolulu, HI 96813

Counties

Mayor Jeremy Harris  
City and County of Honolulu  
630 South King Street  
Honolulu, HI 96813

Other Interested Parties

Dr. Isabella Abbott  
Botany Department  
University of Hawaii  
3190 Maile Way  
Honolulu, HI 96822

Amy Greenwell Botanical Garden  
P.O. Box 1050  
Captain Cook, HI 96704

Ms. Winona Char  
4471 Puu Panini Ave.  
Honolulu, HI 96816

Dr. Sheila Conant (\*\*)  
Zoology Department  
University of Hawaii at Manoa  
Honolulu, HI 96822

Mr. Ranjit Cooray  
Harold L. Lyon Arboretum  
3860 Manoa Road  
Honolulu, HI 96822

Matthew Ford (\*\*)  
Royal Botanic Gardens  
Kew, Richmond  
Surrey TW9 3AB  
United Kingdom

Ms. Evangeline Funk  
Botanical Consultants  
P.O. Box 90765  
Honolulu, HI 96835

Mr. Bill Garnett  
59753 Alapio St.  
Haleiwa, HI 96712

Dr. Robert Gustafson  
Museum of Natural History  
900 Exposition Blvd.  
Los Angeles, CA 90007

Hawaii Audubon Society  
850 Richards Street  
Honolulu, HI 96813-4709

Hawaiian Botanical Society  
c/o Botany Department  
University of Hawaii, Manoa  
3190 Maile Way  
Honolulu, HI 96822

Hawaii Natural Heritage Program  
The Nature Conservancy of Hawaii  
1116 Smith Street, Suite 201  
Honolulu, HI 97817

Hawaii Nature Center  
2131 Makiki Heights Dr.  
Honolulu, HI 96822

Dr. Derral Herbst (\*\*)  
Bishop Museum  
Botany Department  
P.O. Box 19000-A  
Honolulu, HI 96817

Mr. Donald R. Hodel  
University of California, Cooperative Extension  
2615 S. Grand Ave., Suite 400  
Los Angeles, CA 90007

Mr. Clyde Imada  
Botany Department  
Bishop Museum  
P.O. Box 19000-A  
1525 Bernice St.  
Honolulu, HI 96817

Dr. William Klein (deceased)  
Director, National Tropical Botanical Garden  
P.O. Box 340  
Lawai, HI 96765

Mr. Greg Koob (\*\*)  
P.O. Box 12191  
Honolulu, HI 96828

Director  
Honolulu Botanical Gardens  
50 N. Vineyard  
Honolulu, HI 96817

Dr. David Lorence  
National Tropical Botanical Garden  
P.O. Box 340  
Lawai, HI 96765

Mr. Bert Lum  
P.O. Box 152  
Honolulu, HI 96810

Dr. Steven Montgomery  
Conservation Council of Hawaii  
P.O. Box 2923  
Honolulu, HI 96802

The Nature Conservancy of Hawaii  
1116 Smith Street, Suite 201  
Honolulu, HI 97817



Dr. Daniel Palmer  
197 Judd Hillside Street  
Honolulu, HI 96822

Dr. Diane Ragone  
National Tropical Botanical Garden  
P.O. Box 340  
Lawai, HI 96765

Dr. Robert Read  
Department of Botany  
National Museum of Natural History  
Smithsonian Institution  
Washington, D.C. 20560

Ms. Joshlyn Sand (\*\*)  
Honolulu Botanic Gardens  
50 N. Vineyard Blvd.  
Honolulu, HI 96817

Secretariat for Conservation Biology  
University of Hawaii at Manoa  
Pacific Biomedical Research Center  
3050 Maile Way, Gilmore 310  
Honolulu, Hawaii 96822

Mr. Michael Sherwood  
Earthjustice  
180 Montgomery St., Suite 1400  
San Francisco, CA 94109

Sierra Club  
P.O. Box 2577  
Honolulu, HI 96803

Dr. Clifford W. Smith  
University of Hawaii  
Department of Botany  
3190 Maile Way  
Honolulu, HI 96822

Mr. Jan Tenbruggencate  
Honolulu Advertiser  
P.O. Box 524  
Lihue, HI 96766-0524

University of Hawaii  
Department of Botany  
3190 Maile Way, Room 101  
Honolulu, HI 96822

Dr. Kerry Walter  
World Conservation Monitoring Centre  
219 Huntington Rd.  
Cambridge CB3 0DL, England

Dr. Stephen Weller (\*\*)  
Department of Ecology and Evolutionary Biology  
University of California  
Irvine, California 92717

Mr. Ken Wood  
National Tropical Botanical Garden  
P.O. Box 340  
Lawai, HI 96765

Ms. Marjorie F.Y. Ziegler  
Earthjustice  
223 South King Street  
Austin Building, Suite 400  
Honolulu, HI 96813

Zoology Department  
University of Hawaii  
2538 The Mall  
Honolulu, HI 96822

(\* ) Provided comments on the Draft Recovery Plan

(\*\* ) Provided information used in the development of the Draft Recovery Plan

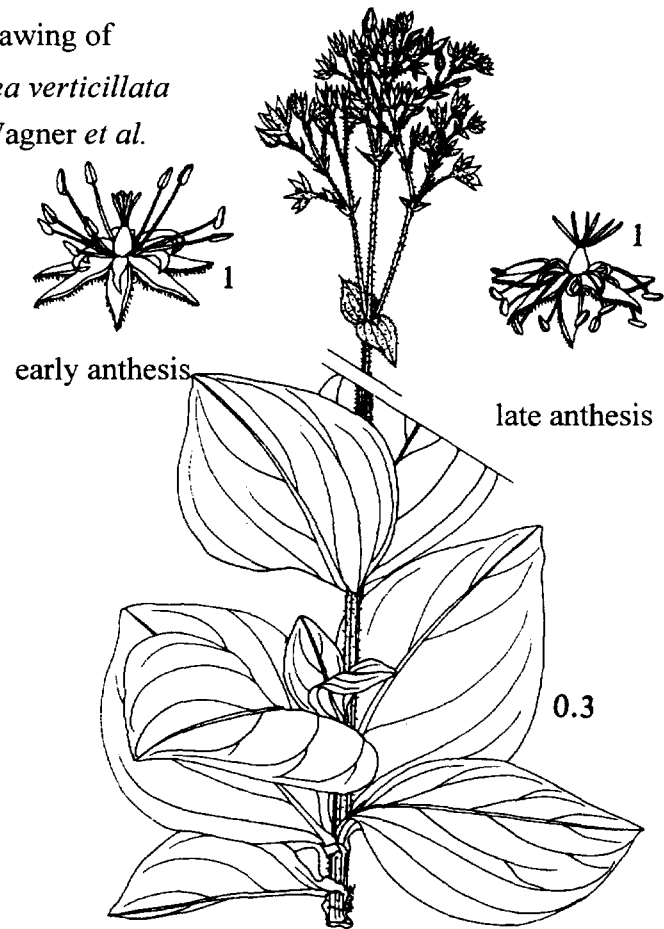
## **APPENDIX B - LINE DRAWINGS OF PLANTS**

No line drawings were available for *Pritchardia remota*.

Line drawing of  
*Amaranthus brownii*  
from Wagner *et al.*  
(1990).

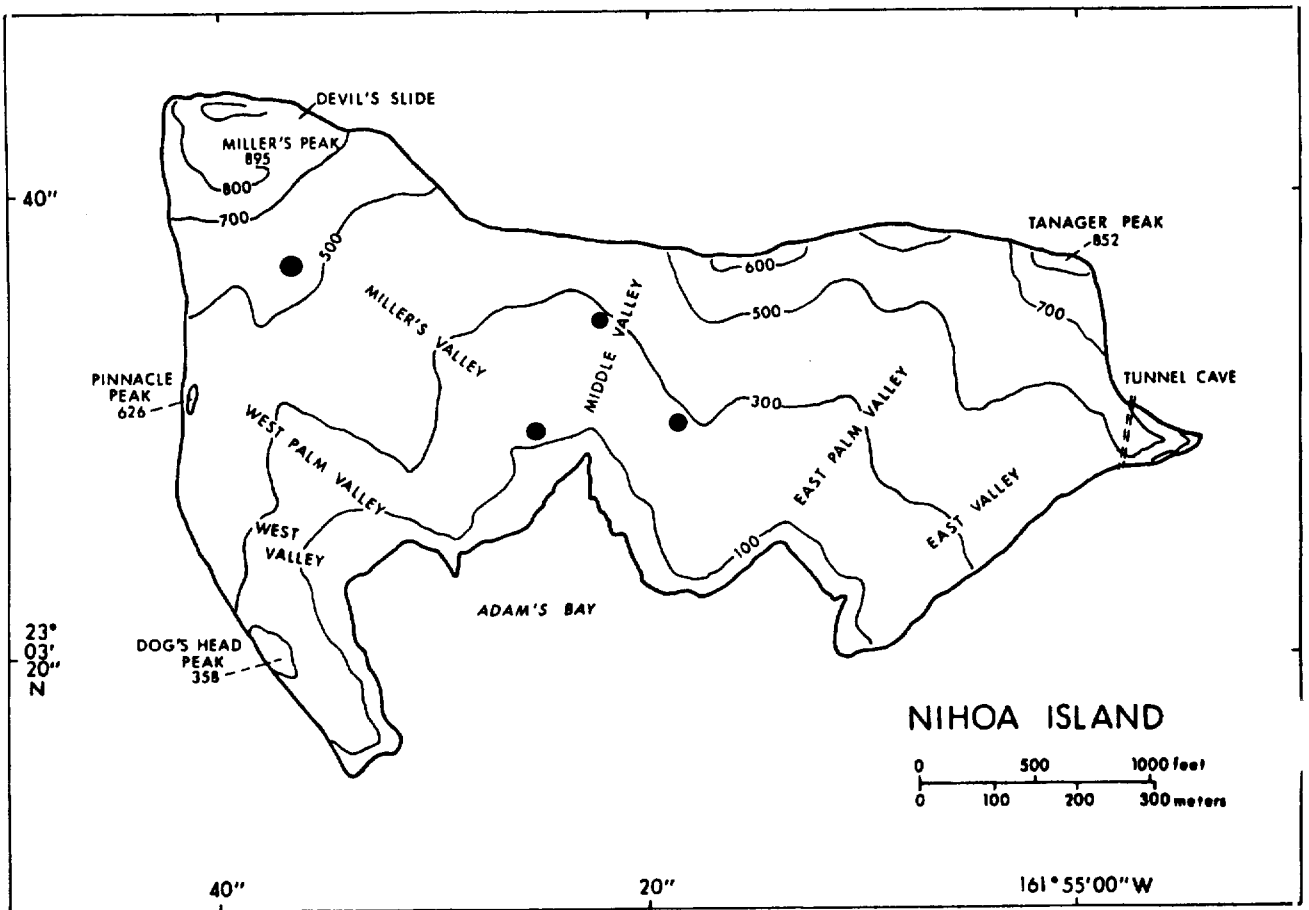


Line drawing of  
*Schiedea verticillata*  
from Wagner *et al.*  
(1990).



## APPENDIX C - MAPS OF CURRENT RANGE

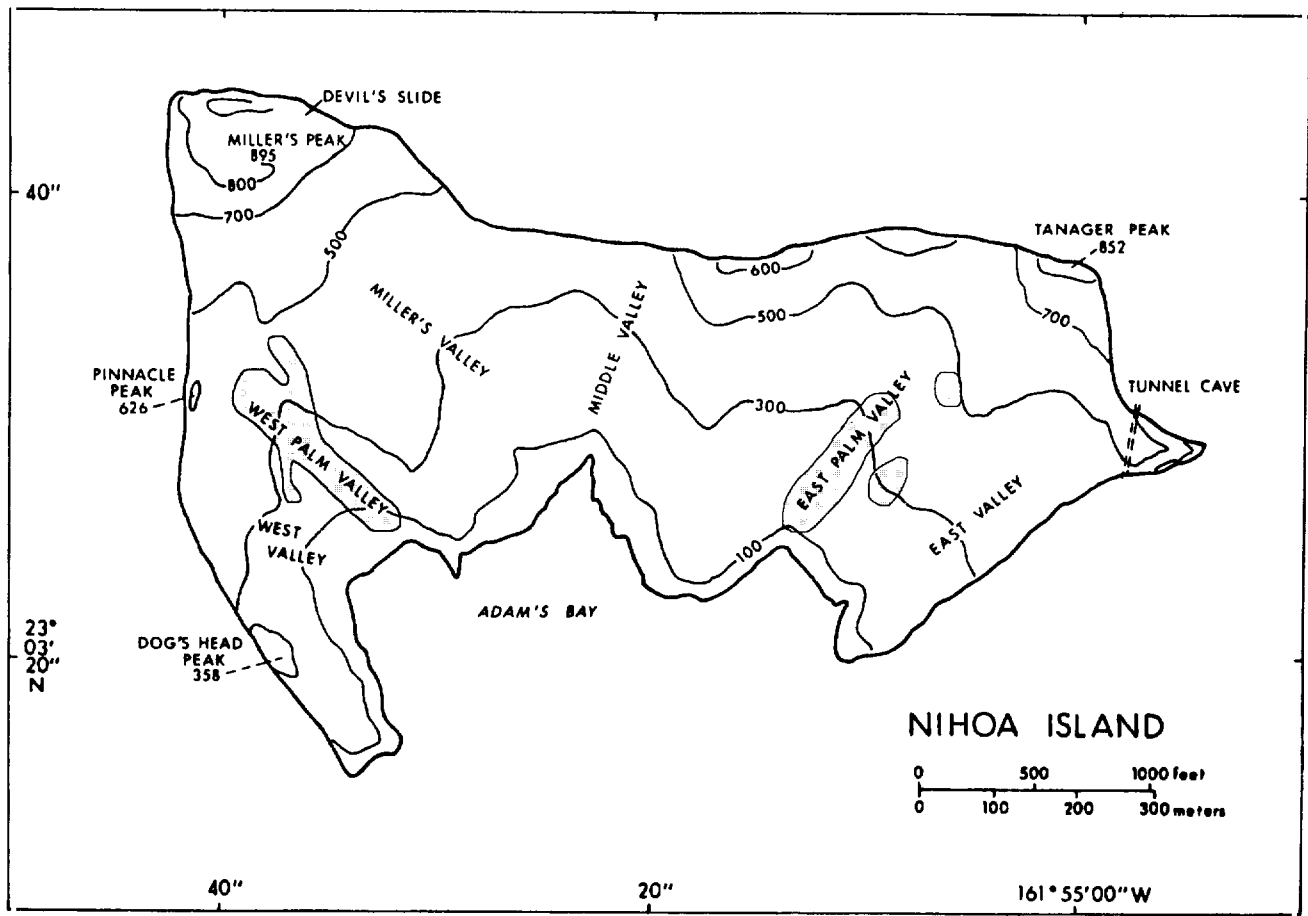
Maps of current ranges of the three Nihoa taxa are based on the most recent data available, which ranges from 1980 to 1997. There are no maps of historic distributions. However, reports from a 1923 expedition indicated that *Amaranthus brownii* was once “common” on Miller Ridge and “abundant” on the ridges to the east (Conant 1985). General descriptions and counts for *Pritchardia remota* and *Schiedea verticillata* indicate that the location and size of colonies has remained relatively constant.



● = 1983 location

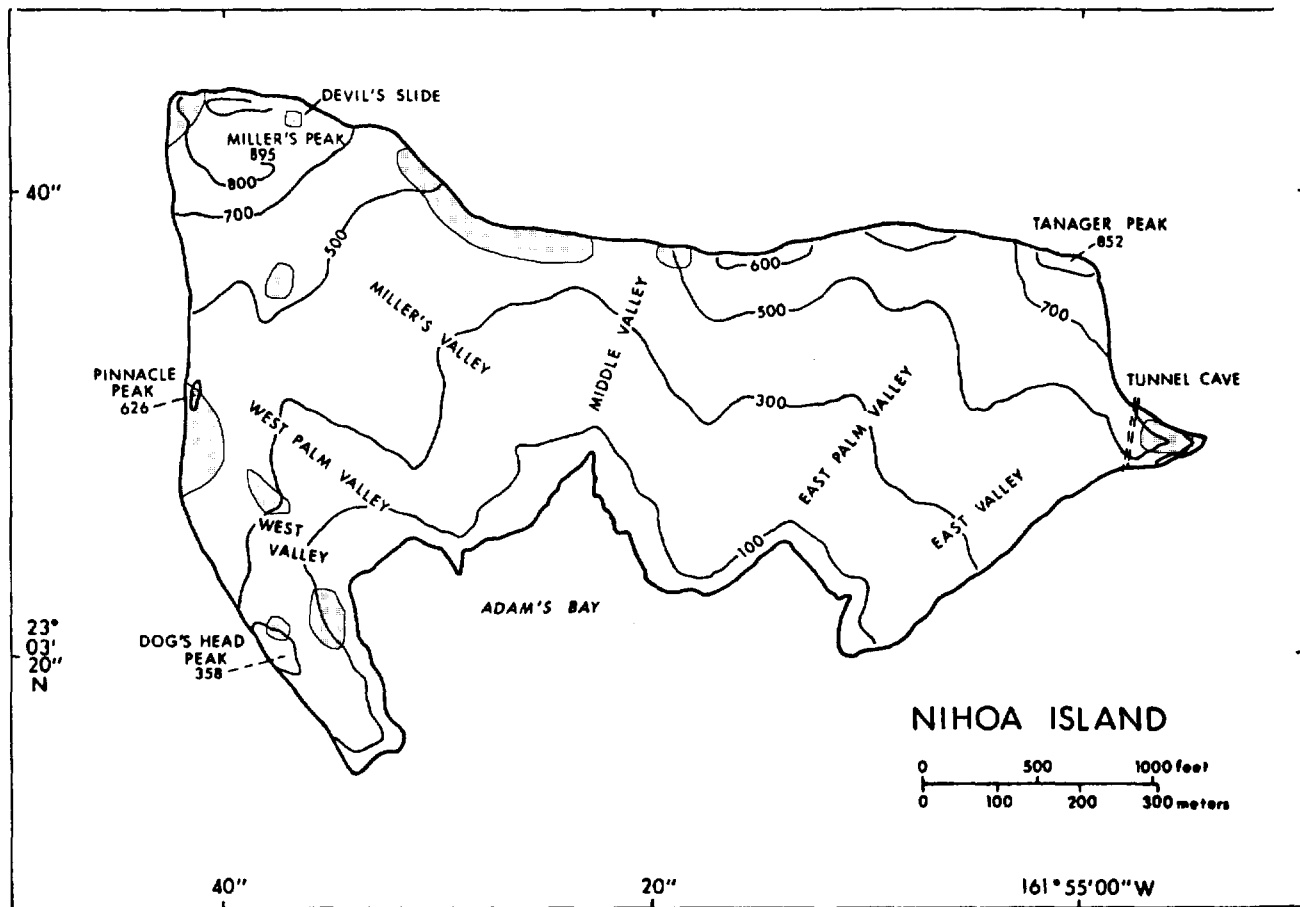
Locations of *Amaranthus brownii* colonies on Nihoa Island (Conant 1985).





○ = 1996 location

Locations of *Pritchardia remota* colonies on Nihoa Island (Rowland 1997).



○ = 1996 location

Locations of *Schiedea verticillata* colonies on Nihoa Island (Rowland 1997).

## **APPENDIX D - RECOVERY PRIORITY SYSTEM**

The Recovery Priority System uses the criteria of (1) degree of threat, (2) recovery potential, and (3) taxonomy (level of genetic distinctiveness). By applying these criteria, all listed species are assigned a species priority number of 1 through 18. A fourth factor, conflict, is a supplementary element in determining what actions are to be implemented for recovery of a species. In addition, the fourth factor gives priority, within each category, in preparation of recovery plans to those species that are, or may be in conflict with construction or development projects. Thus, the species retains its numerical rank and acquires the letter designation of "C," indicating conflict (1C-18C).

A detailed discussion of the Recovery Priority System can be found in FR Vol. 48, No. 221, Pg. 51985 of the issue Tuesday, November 15, 1983.

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic genus	1	1C 1
	High	Species	2	2C 2
	High	Subspecies	3	3C 3
	Low	Monotypic genus	4	4C 4
	Low	Species	5	5C 5
	Low	Subspecies	6	6C 6
Moderate	High	Monotypic genus	7	7C 7
	High	Species	8	8C 8
	High	Subspecies	9	9C 9
	Low	Monotypic genus	10	10C 10
	Low	Species	11	11C 11
	Low	Subspecies	12	12C 12
Low	High	Monotypic genus	13	13C 13
	High	Species	14	14C 14
	High	Subspecies	15	15C 15
	Low	Monotypic genus	16	16C 16
	Low	Species	17	17C 17
	Low	Subspecies	18	18C 18

## **APPENDIX E - SUMMARY OF COMMENTS**

The U.S. Fish and Wildlife Service received comment letters on the Draft Recovery Plan for Three Plant Species on Nihoa Island from the Hawaii Department of Land and Natural Resources' Division of Forestry and Wildlife, the Office of Hawaiian Affairs, and the State Land Use Commission. These comments consisted of minor editorial suggestions and have, for the most part, been incorporated into the final plan.