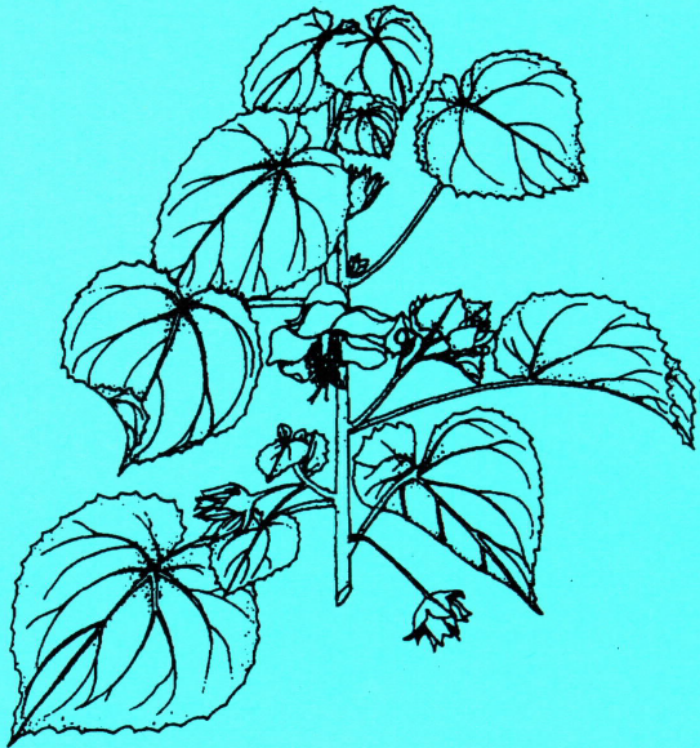


LANA'I PLANT CLUSTER RECOVERY PLAN

SEPTEMBER, 1995

U.S. Fish and Wildlife Service, Pacific Region



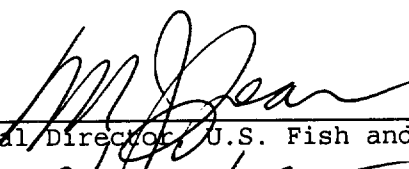
Abutilon menziesii, one of nine plants in the Lana'i Plant Cluster.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island Territories under U.S. administration.

LANA'I PLANT CLUSTER RECOVERY PLAN

Published by
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: _____


Regional Director, U.S. Fish and Wildlife Service

Date: _____

7/29/95

THIS IS THE COMPLETED RECOVERY PLAN FOR THE LANA'I CLUSTER PLANTS. IT DELINEATES REASONABLE ACTIONS THAT ARE BELIEVED TO BE REQUIRED TO RECOVER AND/OR PROTECT THE SPECIES. OBJECTIVES WILL BE ATTAINED AND ANY NECESSARY FUNDS MADE AVAILABLE SUBJECT TO BUDGETARY AND OTHER CONSTRAINTS AFFECTING THE PARTIES INVOLVED, AS WELL AS THE NEED TO ADDRESS OTHER PRIORITIES. THIS RECOVERY PLAN DOES NOT NECESSARILY REPRESENT OFFICIAL POSITIONS OR APPROVALS OF THE COOPERATING AGENCIES, AND IT DOES NOT NECESSARILY REPRESENT THE VIEWS OF ALL INDIVIDUALS WHO PLAYED A ROLE IN PREPARING THE PLAN. IT IS SUBJECT TO MODIFICATION AS DICTATED BY NEW FINDINGS, CHANGES IN SPECIES STATUS, AND COMPLETION OF TASKS DESCRIBED IN THE PLAN.

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Joel Lau (of The Nature Conservancy of Hawaii) has unsurpassed knowledge of the current status of rare plants of Lana'i. He was instrumental in the preparation of invaluable Hawaiian Heritage Program maps that established much of the initial infrastructure of this project, and he provided excellent field notes and other essential information.

Finally, we would like to recognize the superb knowledge and field expertise of Robert W. Hobdy, assistant district forester for the Maui Division of Forestry and Wildlife. Bob was raised on Lana'i, examining plants there as a young boy as a field assistant of the renowned Hawaiian biologist, Dr. Otto Degener. Bob's

contributions have greatly enhanced the accuracy and depth of this work. We gratefully acknowledge his full and unselfish efforts.

LANA'I PLANT CLUSTER RECOVERY PLAN
EXECUTIVE SUMMARY

Current Species Status: All nine taxa are federally listed as endangered with numbers of known remaining individuals as follows: Abutilon eremitopetalum, 7; A. menziesii, fewer than 700; Cyanea macrostegia ssp. gibsonii, 75-80; Cyrtandra munroi, fewer than 50; Gahnia lanaiensis, fewer than 50; Phyllostegia glabra var. lanaiensis, none known; Santalum freycinetianum var. lanaiense, more than 275; Tetramolopium remyi, 2; and Viola lanaiensis, fewer than 80. Cyanea macrostegia ssp. gibsonii, Cyrtandra munroi, Gahnia lanaiensis, Phyllostegia glabra var. lanaiensis and Viola lanaiensis have their main distributions in the Lana'ihale area of Lana'i. Abutilon eremitopetalum, Abutilon menziesii and Tetramolopium remyi have their main distributions in the lowland dry forests of Lana'i. Santalum freycinetianum var. lanaiense is found in a wide range of habitats on Lana'i and Maui. Cyrtandra munroi is also found on Maui, and Abutilon menziesii is also found on Maui, Hawai'i and possibly Oahu.

Habitat Requirements and Limiting Factors: The habitat of the Lana'ihale taxa is diverse, mixed, mesic to wet Metrosideros forest from 300 to 920 meters (984 to 3,018 feet). The habitat of the lowland dry forest species is Erythrina/Diospyros woodland and Leucaena or Dodnaea/Heteropogon shrublands from 150 to 520 meters (500 to 1710 feet). The most serious threats to all nine taxa are browsing and trampling by introduced ungulates, and competition from alien plants. Fire, seed predation, loss of pollinators and disease also threaten these taxa. Agricultural and urban development threaten populations on Maui and Hawaii.

Recovery Objective: Delist all taxa. Interim, downlisting and delisting objectives are provided.

Recovery Criteria:

Interim Objectives

The interim objective is to stabilize all existing populations of the Lanai taxa. To be considered stable, each taxon must be managed to control threats (e.g., fenced) and be represented in an ex situ collection. In addition, a minimum total of three populations of each taxon should be documented on Lanai and, if possible, at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing and increasing in number, with a minimum of 25 mature individuals per population for long-lived perennials and a minimum of 50 mature individuals per population for short-lived perennials.

Downlisting

These taxa may be downlisted when a total of five to seven populations are documented on Lanai and at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials, and a

minimum of 300 mature individuals per population for short-lived perennials. Each of these populations must persist at this level for at least 5 consecutive years before downlisting is considered.

Delisting

These taxa may be delisted when a total of 8 to 10 populations of each taxon should be documented on Lanai and at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials and a minimum of 300 mature individuals per population for short-lived perennials. Each population should persist at this level for at least 5 consecutive years before delisting is considered.

Actions Needed:

1. Protect habitat of current populations and manage threats.
2. Conduct research essential to conservation of the species.
3. Expand current populations.
4. Establish new populations as needed to reach recovery objectives.
5. Validate and revise recovery objectives.

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

<u>Year</u>	<u>Need 1</u>	<u>Need 2</u>	<u>Need 3</u>	<u>Need 4</u>	<u>Need 5</u>	<u>Total</u>
1994	98.0	0.0	350.0	0.0	0.0	448.0
1995	249.25	297.0	1061.0	68.5	0.0	1676.0
1996	1117.5	297.0	1061.0	473.5	0.0	2949.0
1997	1138.5	302.0	1061.0	443.5	0.0	2945.0
1998	531.9	302.0	1061.0	443.5	0.0	2338.4
1999	476.9	302.0	1061.0	443.5	0.0	2283.4
2000	359.4	182.0	665.0	872.0	0.0	2078.4
2001	303.4	182.0	665.0	467.0	0.0	1617.4
2002	303.4	182.0	665.0	467.0	0.0	1617.4
2003	303.4	182.0	665.0	467.0	0.0	1617.4
2004	303.4	182.0	315.0	467.0	0.0	1267.4
2005	303.4	37.0	0.0	467.0	0.0	807.4
2006	258.4	37.0	0.0	467.0	0.0	762.4
2007	258.4	37.0	0.0	467.0	0.0	762.4
2008	258.4	37.0	0.0	467.0	0.0	762.4
2009	258.4	37.0	0.0	467.0	0.0	762.4
2010	258.4	37.0	0.0	62.0	0.0	357.4
2011	258.4	37.0	0.0	62.0	9.0	371.4
2012	258.4	37.0	0.0	62.0	9.0	366.4
2013	258.4	37.0	0.0	62.0	15.0	372.4
2014	258.4	37.0	0.0	62.0	6.0	363.4
2015	258.4	37.0	0.0	62.0	6.0	363.4
Total	7853.7	2817.0	8630.0	7319.5	45.0	26665.2

Date of Recovery: Downlisting to Threatened should initiate in 2015, if recovery criteria are met.

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* Appendix B is not included in the general distribution of this Plan due to the possibility that vandalism or unauthorized collection could be encouraged by the public release of this information. The U.S. Fish & Wildlife Service will consider requests for the maps on a case by case basis.

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PART I. INTRODUCTION

1. BRIEF OVERVIEW

Statement of problem and objectives

This recovery plan addresses nine plant taxa from the island of Lana'i, Hawai'i, which have been listed as endangered under the Endangered Species Act of 1973, as amended (ESA), in four listing actions between January 1986 and May 1992: Abutilon eremitopetalum Caum (USFWS 1991); Abutilon menziesii Seem. (USFWS 1986a); Cyanea macrostegia Hillebr. subsp. gibsonii (Hillebr.) Lammers (USFWS 1991); Cyrtandra munroi C. Forbes (USFWS et al. 1992); Gahnia lanaiensis Degener, I. Degener, & J. Kern (USFWS 1991); Phyllostegia glabra (Gaud.) Benth. var. lanaiensis Sherff (USFWS 1991); Santalum freycinetianum Gaud. var. lanaiense Rock (USFWS 1986b); Tetramolopium remyi (A. Gray) Hillebr. (USFWS 1991); and Viola lanaiensis W. Becker (USFWS 1991). The ultimate objective of this plan is to provide a framework for the eventual recovery of these nine taxa to the extent possible, preferably so that their protection by the ESA is no longer necessary. This plan summarizes available information about each taxon, reviews the threats posed to their continued existence, and lists management actions that are needed to remove these threats.

Immediate actions necessary for the prevention of extinction of these taxa include fencing for exclusion of ungulates, alien plant control, protection from fire, population and plant community monitoring and management, ex situ propagation, and augmentation of populations, as appropriate. Long-term activities necessary for the perpetuation of these taxa in their natural habitats additionally include baseline and long-term research regarding growth requirements, public education, maintenance of fenced areas, long-term monitoring and management of populations and communities, and re-establishment of populations within the historic ranges of some taxa. Further research regarding current range, reproduction and reproductive status, pollinators, life history, limiting factors, habitat requirements, and minimum viable population sizes is needed to facilitate appropriate management decisions regarding the long-term perpetuation of each of these taxa.

Geologic and Evolutionary Setting of the Hawaiian Islands and Lana'i

Islands are microcosms of the biosphere in space and time, with evolution proceeding in partial isolation from that on continents and other islands. In the Hawaiian Islands, located over 4,000 kilometers (2,500 miles) from the nearest continent, the isolation from other lands was, until recently, almost complete. The first volcanoes of the chain rose from the central part of the ancestral Pacific Ocean about 70 million years ago. Individual islands were formed, matured, and eroded to sea level in cycles lasting about 10 million years. New islands were continually being formed as the Pacific Plate drifted northwestward. The main Hawaiian Islands now range in age from under 1 million years (Hawai'i) to 5.8 million years (Kaua'i). The oldest dated rocks from Lana'i are 1.46 million years old; geological evidence suggests an age of 30-40 million years for the now largely eroded older islands in the Leeward Hawaiian chain and 70 million years for islands further to the northwest (Macdonald et al. 1983).

Plant seeds and animals from other lands reach newly formed volcanic islands very rarely because there are few means available for colonization. Such means include floating in the ocean or being carried by air currents or birds. Plants and animals ancestral to native Hawaiian species (totalling about 1000 ancestors) colonized the Hawaiian Islands at the rate of about one species per 70,000 years over the 70 million year history of the archipelago. The modern Hawaiian flowering plant flora (approximately 1000 species) evolved from about 272 colonizing ancestors (Fosberg in Zimmerman 1948).

As a developing isolated archipelago with high mountains, subtropical climate, and abundant rainfall, ancient Hawai'i provided a remarkable opportunity for the plants and animals that arrived early. Biological vacancies existed and species developed to fill these niches. Over millions of years of evolution, ecosystems of the Hawaiian Islands became increasingly rich in species of plants and animals. In modern times, botanists have found 345 species of native vascular plants on Lana'i, 8 of which are endemic to that island (Hobdy 1993).

Disruption of Island Ecosystem Development on Lana'i

The processes of colonization and island evolution continued uninterrupted until Polynesians arrived in the Islands in about the 4th century A.D. At the time of western contact in the late 1700s, the human population of Lana'i was between 3,000 and 3,250, and agriculture was well established. In 1778, just a few months before Captain James Cook's first visit to the Hawaiian Islands, nearly the entire human population of Lana'i was wiped out by a raid by other Hawaiian warriors. Erosion of some uplands areas of Lana'i probably began after these raids, in which most human improvements to the island--as well as the food supplies and crops--were destroyed (Hobdy 1993).

The native vegetation of Lana'i remained basically intact at the time of Cook's arrival (Hobdy 1993). Introduction of hoofed mammals has since led to massive ecosystem deterioration. Goats (Capra hircus) and European hogs (Sus scrofa) were first brought to Lana'i in 1778, sheep (Ovis aries) in 1791, and cattle (Bos taurus) in 1793 (Tomich 1986). Noticeable damage to native vegetation was noted within 30 years of introduction of these animals to the island. Lydgate (1921), writing of a trip taken to Lana'i in 1869, stated, "Lanai, even in those early days, had been pretty well denuded of its forest cover; only on the summit of the island ridge was there a somewhat moth-eaten mantle of it left, and only on the slopes of the higher ravines and the steep hillsides was that mantle really intact and undisturbed."

By 1898, 50,000 sheep roamed free on Lana'i (Allton 1991). Ornithologist and conservationist George C. Munro became the manager of the Lana'i Company in 1911 and spent much time controlling sheep and goats to prevent destruction of the vegetation. As a result, the prognosis for the island's ecosystems was not highly unfavorable as recently as the 1930s (e.g. Fosberg 1936a). Populations of sheep never recovered from Munro's efforts and the last feral goats were removed from the island in 1981.

A total of 12 axis (Axis axis) deer were taken to Lana'i from Moloka'i in 1920 to provide a desirable game animal (Tomich 1986). After goats were eradicated, the deer population exploded. By 1984, the deer began to occupy and utilize canyon slopes and cliffs previously thought to be too steep for them (Hobdy 1993). By 1988, axis deer numbered more than 10,000 on Lana'i; damage to the landscape, fauna and flora increased dramatically (Allton

1991). Mouflon sheep were introduced in 1954 and the population increased rapidly (Tomich 1986). The consequences of years of degradation are that only 2% of the dryland forest and only 30% of the cloud forest (approximately 200 hectares (500 acres)) on Lana'i remain. Seventy native plant taxa have been extirpated (including three Lana'i endemics), and only one of eight endemic forest bird taxa, the Lana'i apapane (Himatione sanguinea), originally present on Lana'i remains (Allton 1991; Hobdy 1993). For further information, refer to Robert Hobdy's (1993) article Lana'i - A Case Study: The Loss of Biodiversity on a Small Hawaiian Island.

Urgency of Preservation of Native Biological Diversity on Lana'i

Having evolved in long isolation from many of the evolutionary forces that shape continental organisms, island organisms are highly vulnerable when such forces are introduced to their environments. The vulnerability of Lana'i's biota to browsing and trampling by hoofed mammals is a classic example of this generalization.

The native flora and fauna of Lana'i are in a severely reduced state. Small remnants of native communities persist: perhaps 3% of the original coastal and strand community; 20% of the (much degraded) arid grassland and shrubland community; about 30% of the original cloud forest community; and only about 2% of the dry forest community remains (Hobdy 1993). Hobdy (1993) states, "The agents that have brought about the present levels of decline are for the most part still present and continue to exert their influence. Lana'i's native ecosystems have suffered severe disintegration of their many interactive components and are experiencing what may be termed catastrophic collapse."

This recovery plan is part of a last-ditch effort to salvage some of the most endangered biological diversity of a highly degraded island ecosystem. The importance of this effort is underscored by the significance of Hawai'i as the world's best natural laboratory for evolutionary studies (Williamson 1981; Kaneshiro 1989). Evolutionary studies on the native biota of Hawai'i have been extremely important in the development of modern theories of speciation and evolution, with many practical spinoffs (molecular genetics, genetic engineering, and other biotechnology). It has been argued that Hawai'i's native biota is its single most important resource (Kaneshiro 1989).

2. DESCRIPTION AND TAXONOMY

The description and taxonomy of each Lana'i cluster plant will be discussed individually. Descriptions are based on the Federal Register documents designating each taxon as endangered (USFWS 1986a, 1986b, 1991; USFWS et al. 1992). The taxonomy of each plant is based on information from original publications whenever possible. Author designations follow those in Wagner et al. (1990).

A. Abutilon eremitopetalum Caum

Description

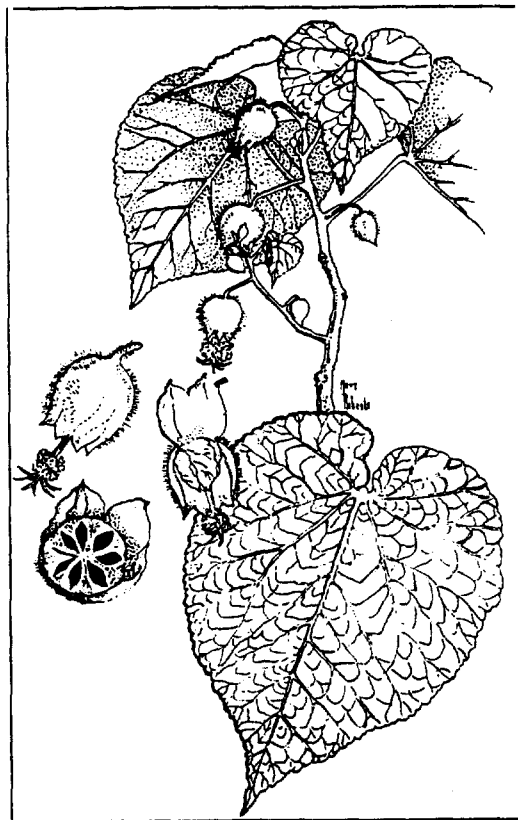


Figure 1. Abutilon eremitopetalum

Abutilon eremitopetalum (Figure 1, from Degener 1933) is a shrub in the mallow family (Malvaceae) with grayish-green, densely hairy, heart-shaped leaves; the leaves are 7 to 12 centimeters (2.7 to 4.7 inches) long. One or two flowers are on stems up to 4 centimeters (1.6 inches) long in the leaf axils. The calyx of the

flowers is green, cup-shaped, and about 1.5 centimeters (0.6 inches) long. The petals are shorter than the calyx and are bright green on the upper surface and reddish on the lower surface. The staminal column extends beyond the calyx and is white to yellow, with red style branches tipped with green stigmas. The fruit is a hairy, brown, dry, cylindrical capsule and about 1 centimeter (0.4 inches) long. It is the only Abutilon on Lana'i whose flowers have green petals hidden within the calyx (Bates in Wagner et al. 1990).

Taxonomy

Abutilon eremitopetalum was originally described as Abutilon cryptopetalum with type specimen listed as one collected by George C. Munro in 1930 from Maunalei Valley, Lana'i (Caum 1933). The specific epithet refers to, "the very small... petals, which are at all times completely enclosed within the calyx" (Caum 1933). However, unbeknownst to Caum at the time of his original publication, the epithet Abutilon cryptopetalum had already been assigned to an Australian species (Degener 1936). Caum renamed the species Abutilon eremitopetalum (Caum in Christophersen 1934). In 1932, Otto Degener established the genus Abortopetalum (Degener 1932) and in 1936 included this species in that genus as Abortopetalum eremitopetalum (Degener 1936). However, Christophersen points out that Degener's Abortopetalum does not differ from Abutilon in characters of generic rank (Christophersen 1934); the most recent revision of the Hawaiian flora supports Christophersen's conclusion (Bates in Wagner et al. 1990). Therefore, the current designation for this plant is Abutilon eremitopetalum.

B. Abutilon menziesii Seem

Description

Abutilon menziesii (Figure 2, from Wagner et al. 1990) is a shrub in the mallow family (Malvaceae) 2-2.5 meters (6.6 to 8.2 feet) tall with coarsely-toothed, silvery, heart-shaped leaves 2-8 centimeters (0.8 to 3.2 inches) long. The flowers are medium red to dark red and about 2 centimeters (0.8 inches) across. The capsules are hairy and five to eight-parted, usually with three seeds per cell.

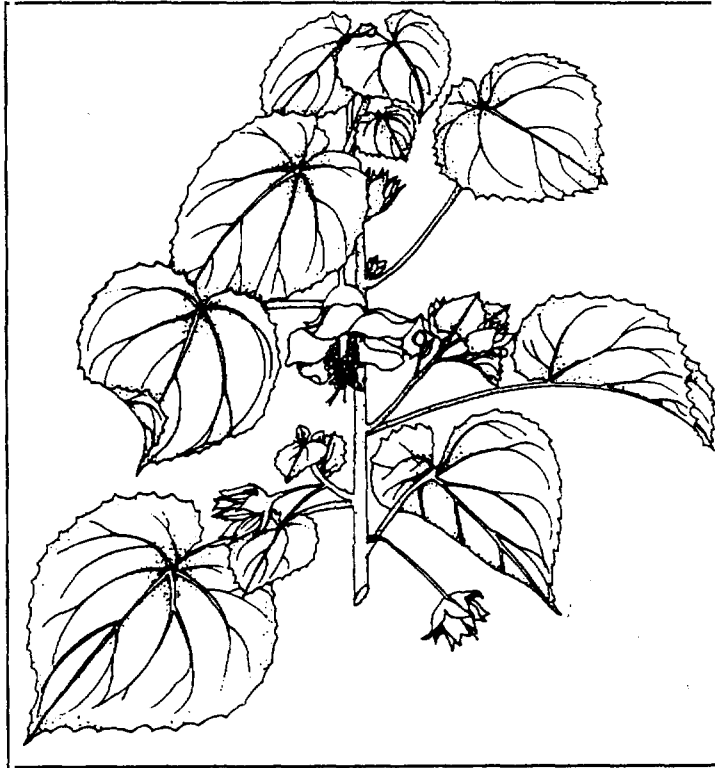


Figure 2. Abutilon menziesii

Taxonomy

Abutilon menziesii was originally described based on two specimens, which were in the British Museum of Natural History, collected by Dr. Archibald Menzies from the "Sandwich Islands" (Seemann 1865-1873). No taxonomic variants of this species have been formally described; however, Hillebrand (1888) recognized a β -variety with "light flesh-colored" flowers from a specimen collected by Lydgate from Lana'i, and it has been noted that specimens from Lana'i have "densely pubescent calyces, pale corollas, and large mericarps" (Bates in Wagner et al. 1990). Although some Lana'i plants have darker petals, nearly all show vestiges of the light coloration (Robert Hobdy, Maui Division of Forestry and Wildlife, personal communication 1992).

C. Cyanea macrostegia ssp. gibsonii Hillebrand

Description

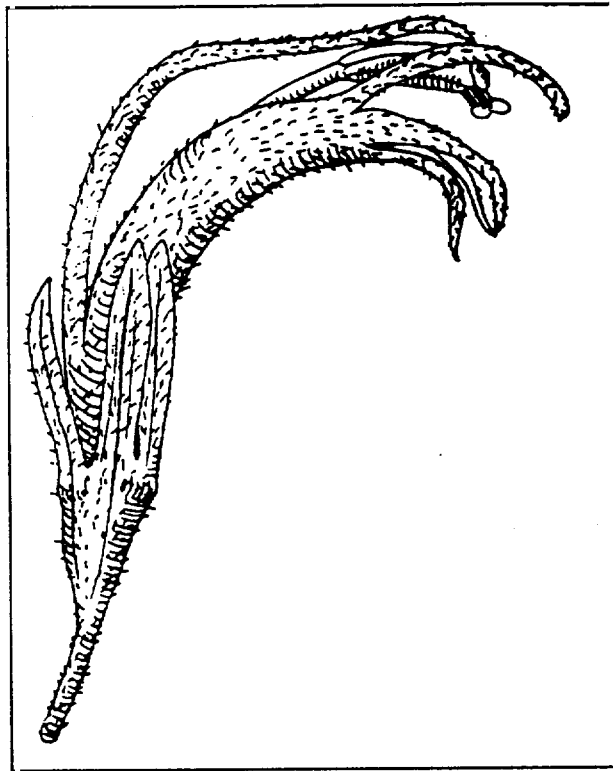


Figure 3. Cyanea macrostegia ssp. gibsonii

Cyanea macrostegia ssp. gibsonii (Figure 3, from Wimmer 1943), a member of the bellflower family (Campanulaceae), is a palm-like tree 1 to 7 meters (3.3 to 23 feet) tall. The leaves are elliptic or oblong, about 20 to 80 centimeters (7.9 to 31.5 inches) long and 6.5 to 20 centimeters (2.6 to 7.9 inches) wide; the upper surface is usually smooth, while the lower is covered with fine hairs. The leaf stem is often covered with small prickles throughout its length. The inflorescences are horizontal and clustered among the leaves, each bearing 5 to 15 curved flowers that are blackish-purple externally and white or pale lilac within. The fruit is a yellowish-orange berry about 1.5 to 3 centimeters (0.6 to 1.2 inches) long. The following combination of characters separates this taxon from the other members of the genus on Lana'i: calyx lobes oblong, narrowly oblong, or ovate in shape; and the calyx and corolla both more than 0.5 centimeters

(0.2 inches) wide (Lammers in Wagner et al. 1990, Rock 1919, Wimmer 1943).

Taxonomy

Cyanea macrostegia ssp. gibsonii was originally described by William Hillebrand as Cyanea gibsonii based on his 1870 collection from Lana'i "on the highest wooded ridge" (Lana'ihale) (Hillebrand 1888). The holotype in the Berlin Herbarium was destroyed in 1943 (USFWS 1991). A photograph of the holotype is held at the Bishop Museum herbarium [#45040]. Subsequently, an isotype in the National Herbarium of Victoria, Melbourne, Australia was designated as the lectotype (Lammers 1988). Harold St. John (1987) reclassified all Cyanea to Delissea (St. John 1987) because of questions of the validity of characters used to delineate the genus Cyanea (St. John and Takeuchi 1987); however, St. John's changes were not recognized by the latest revision of Hawaii's flora (Lammers in Wagner et al. 1990). Lammers (1988) reclassified Cyanea gibsonii to subspecific status within Cyanea macrostegia due to similarities between the taxa also noted by other botanists (Rock 1919, Wimmer 1943).

D. Cyrtandra munroi C. Forbes

Description

Cyrtandra munroi of the African violet family (Gesneriaceae) is a shrub with opposite, elliptic to almost circular leaves, 9.5 to 21 centimeters (3.7 to 8.3 inches) long and 5.5 to 9.5 centimeters (2.2 to 3.7 inches) wide, which are sparsely to moderately hairy on the upper surface and covered with velvety, rust-colored hairs underneath. The flowers are usually arranged in clusters of three on stalks emerging from the leaf axils. The white petals are fused into a tube, 15 to 20 millimeters (0.6 to 0.8 inches) long, which flares into two upper lobes, 3 millimeters (0.1 inch) long, and three lower lobes, about 5 to 6 millimeters (0.2 to 0.23 inches) long. The white berries, covered with fine hair, are somewhat egg-shaped and 1.8 to 2.3 centimeters (0.7 to 0.9 inches) long. This species is distinguished from other species of the genus by the broad opposite leaves, the length of the flower cluster stalks, the size of the flowers, and the amount

of hair on various parts of the plant (Forbes 1920, Wagner et al. 1990).

Taxonomy

Cyrtandra munroi was originally described in 1920 from specimens collected by G.C. Munro and C.N. Forbes; a specimen collected by Forbes in 1913 from the mountains of eastern Lana'i was designated as the type (Forbes 1920). Cyrtandra munroi belongs to Hillebrand's section Crotonocalyces, resembling certain forms of Cyrtandra platyphylla in the shape of its leaves, but is more closely allied to the species belonging to this section, which occur on the island of Maui. The leaves of a specimen collected by Munro from Wai'opa, Lana'i are "unequal sided" (Forbes 1920).

E. Gahnia lanaiensis Degener, I. Degener, & J. Kern

Description

Gahnia lanaiensis (Figure 4, from Degener et al. 1964), a member of the sedge family (Cyperaceae), is a tall (1.5 to 3 meters (4.9 to 9.8 feet)), tufted, perennial, grass-like plant. This sedge may be distinguished from grasses and other genera of sedges on Lana'i by its spirally arranged flowers, its solid stems, and its numerous, three-ranked leaves. Gahnia lanaiensis differs from the other members of the genus on the island by its achenes (seed-like fruits), which are 0.35 to 0.45 centimeters (0.14 to 0.18 inches) long and purplish-black when mature (Koyama in Wagner et al. 1990).

Taxonomy

Gahnia lanaiensis was originally described by Otto and Isa Degener and J.H. Kern from specimens the Degeners collected from Lana'i near Lana'ihale. The type specimen was collected, "east of Munro trail and north of Lana'i-hale, in shrubby rainforest at an elevation of 890 meters" (Degener et al. 1964).

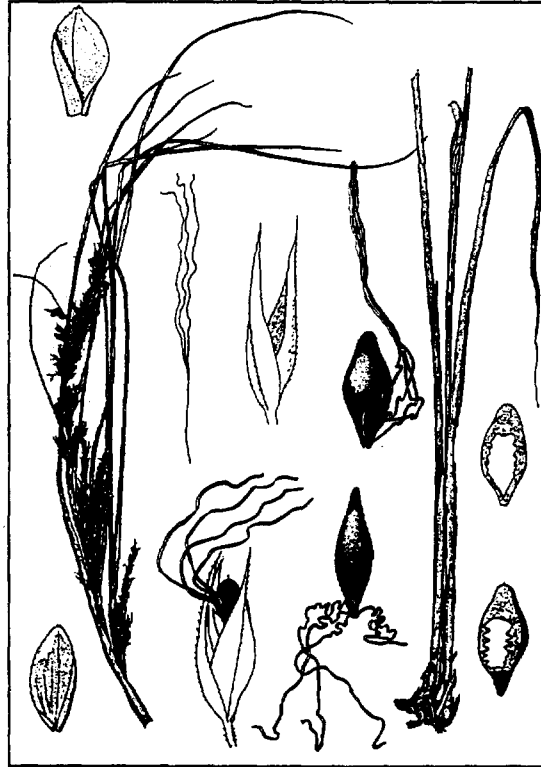


Figure 4. Gahnia lanaiensis

Gahnia lanaiensis seems to be very closely related to Gahnia melanocarpa R.Br. of eastern Australia. The possibility exists that G.C. Munro introduced Gahnia lanaiensis from New Zealand or Australia, either intentionally or accidentally. Therefore, if the taxon is determined to be found elsewhere it may not be native (i.e. neither endemic nor indigenous) to Lana'i (Degener and Degener 1965).

F. Phyllostegia glabra var. lanaiensis Sherf

Description



Figure 5. Phyllostegia glabra var. glabra

Phyllostegia glabra var. lanaiensis (Figure 5, from Wagner et al. 1990, depicts the very similar Phyllostegia glabra var. glabra) is a robust, erect to decumbent (reclining, with the end ascending), glabrous, perennial herb in the mint family (Lamiaceae). Its leaves are thin, narrow, lance-shaped, 8 to 24 centimeters (3.2 to 9.5 inches) long and 1.6 to 2.5 centimeters (0.63 to 0.98 inches) wide, often red-tinged or with red veins, and toothed at the edges. The flowers are in clusters of 6 to 10 per leaf axil, mostly at the ends of branches. The flowers are white, occasionally tinged with purple, and are variable in size, about 1 to 2.5 centimeters (0.39 to 0.98 inches) long. The fruit consists of four small, fleshy nutlets. This variety is very similar to Phyllostegia glabra var. glabra; it may be difficult to differentiate between the two taxa without flowers (Wagner et al. 1990, Fosberg 1936b, Sherff 1935a).

Taxonomy

Phyllostegia glabra var. lanaiensis was described as a variety of Phyllostegia glabra from specimens collected from Lana'i by Ballieu, Munro, and Mann & Brigham. It differs from var. glabra in its longer calyx (10-11 millimeters or 0.3 inches) and narrowly lanceolate leaves (Wagner et al. 1990). The type specimen, at the Field Museum in Chicago, was collected by Mann & Brigham (Sherff 1934).

G. Santalum freycinetianum var. lanaiense Rock

Description

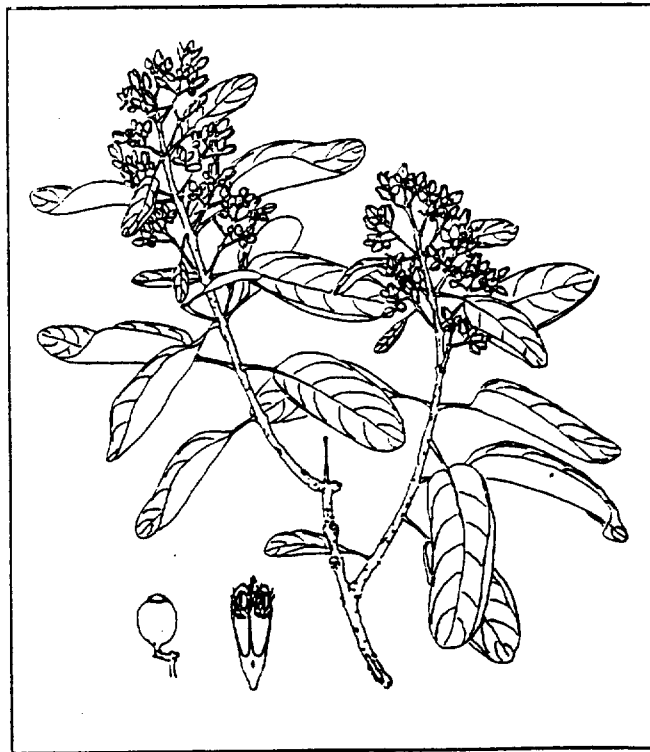


Figure 6. Santalum freycinetianum var. lanaiense

Santalum freycinetianum var. lanaiense (Figure 6, from Stemmermann 1980) is a small, gnarled tree with leaves that vary from nearly round to twice as long as broad, and are dark green on the upper surface. The tree bears small clusters of bright red flowers.

Taxonomy

Santalum freycinetianum var. lanaiense was originally described as having "the largest leaf in the genus and... almost worthy of specific distinction." The type specimen was collected by Rock in 1910 and deposited in the College of Hawaii Herbarium (now the University of Hawai'i) with an isotype in Rock's herbarium (Rock 1913). Three years after Rock originally described the taxon, he elevated it to specific status as Santalum lanaiense (Rock 1916). The latest revision of Hawaii's flora (Wagner et al. 1990) classifies these plants as well as Santalum freycinetianum var. auwahiense of lowland Maui (Stemmermann 1980) as Santalum freycinetianum var. lanaiense.

H. Tetramolopium remyi (A. Gray) Hillebrand

Description

Tetramolopium remyi (Figure 7, from Lowrey 1986), a member of the sunflower family (Asteraceae), is a much branched, decumbent (reclining, with the end ascending) or occasionally erect shrub up to about 40 centimeters (15.8 inches) tall. Its leaves are firm, very narrow, 1.5 to 2.5 centimeters (0.6 to 0.98 inches) long, and with the edges rolled inward when the leaf is mature. There is a single flower head per branch. The heads are 0.9 to 1.5 centimeters (0.4 to 0.6 inches) in diameter and on stalks 4 to 12 centimeters (1.6 to 4.7 inches) tall; each comprises 70 to 100 yellow disk and 150 to 250 white ray florets. The stems, leaves, flower bracts, and fruit are covered with sticky hairs. Tetramolopium remyi has the largest flower heads in the genus. Two other species of the genus are known historically from Lana'i, but both have purplish rather than yellow disk florets and from 4 to 60 rather than 1 flower head per branch (Lowrey 1986, Lowrey in Wagner et al. 1990, Sherff 1935b).

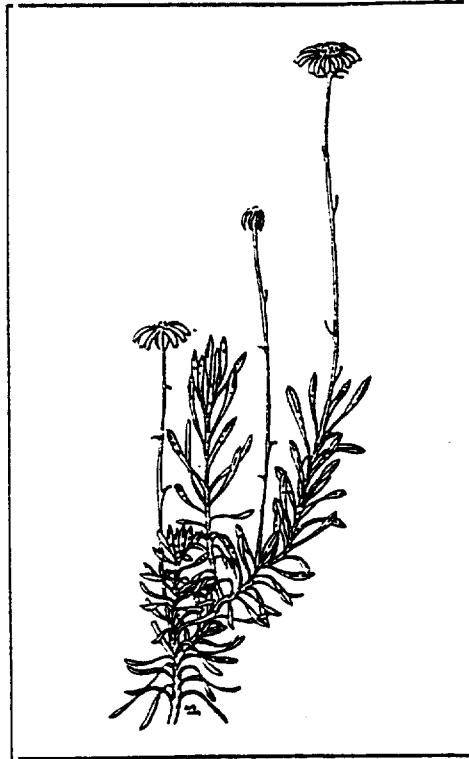


Figure 7. Tetramolopium remyi

Taxonomy

Tetramolopium remyi was originally described by Asa Gray as Vittadinia remyi, as he considered Tetramolopium only a section of Vittadinia based on material collected from Maui by Remy (Gray 1861). The genus Tetramolopium was restored by Hillebrand (1888); this taxon then became known as Tetramolopium remyi. Tetramolopium remyi was placed in the genus Erigeron by Drake del Castillo (1888), but no reason for this action was given and this classification has not been followed by later botanists (e.g. Sherff 1934, Lowrey 1986).

I. Viola lanaiensis W. Becker

Description

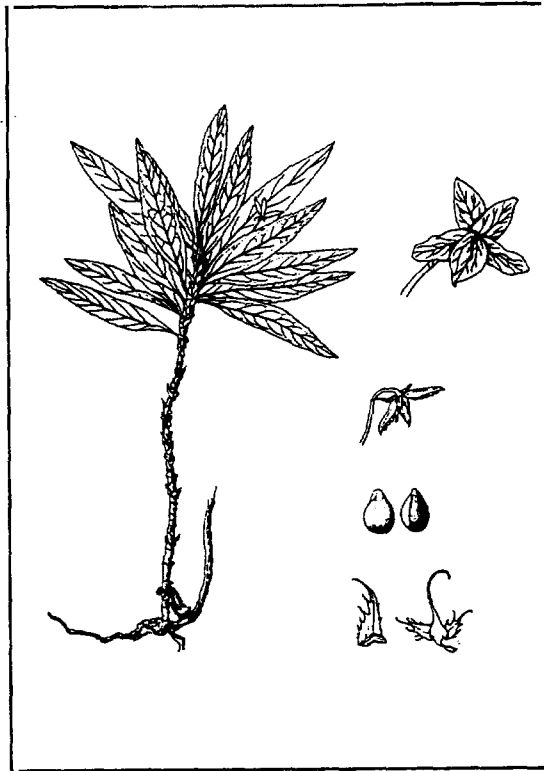


Figure 8. Viola lanaiensis

Viola lanaiensis (Figure 8, from St. John 1989) is a member of the violet family (Violaceae) and is a small, erect, unbranched or little branched subshrub, 10 to 40 centimeters (3.9 to 15.8 inches) tall. The leaves, which are clustered toward the upper part of the stem, are lance-shaped, about 6 to 11 centimeters (2.3 to 4.3 inches) long and 1.3 to 2.5 centimeters (.0.5 to 0.98 inches) wide. Below each leaf is a pair of narrow, membranous stipules, about 0.9 centimeters (0.4 inches) long. The flowers are small, 1.0 to 1.5 centimeters (0.4 to 0.6 inches) long, and white in color tinged with purple or with purple veins, occurring singly or up to four per upper leaf axil. The fruit is a capsule, about 1.0 to 1.3 centimeters (0.4 to 0.5 inches) long. It is the only member of the genus on Lana'i (Becker 1916, MacCaughey 1918, St. John 1989, Skottsberg 1940, Wagner et al. 1990).

Taxonomy

Viola lanaiensis was first formally described by Rock as a variety of Viola helenae (Viola helenae var. lanaiensis) from his own collection of the plants from 1910 (Rock 1911). Before Viola helenae had been described (Forbes 1909), Hillebrand (1888) had noted that a plant collected by Remy on Lana'i was probably Viola robusta. This plant must have been Viola lanaiensis, since it is the only taxon of Viola that occurs on Lana'i (Becker 1916, MacCaughey 1918, St. John 1989, Skottsberg 1940, Wagner et al. 1990). Wilhelm Becker described the taxon as Viola lanaiensis (Becker 1916) independently and without knowledge of Rock's 1911 publication (USFWS 1991). Skottsberg accepted Rock's taxonomy (Skottsberg 1940), but St. John reinstated Becker's designation of the plant as a separate species (St. John 1979).

3. LIFE HISTORY

Little is known about the life histories of most of the Lana'i cluster taxa. The available information regarding reproductive status, suspected or known limiting factors and other factors relevant to each taxon is presented here on a taxon-by-taxon basis.

A. Abutilon eremitopetalum

Little is known about the life history of Abutilon eremitopetalum. It apparently flowers during the wet season (e.g. February) (R. Hobdy, personal communication 1992). Pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

B. Abutilon menziesii

All known populations of Abutilon menziesii are frequently exposed to severe drought and periodic flooding. Due to the presence and abundance of alien grasses surrounding stands of Abutilon menziesii throughout its current range, range expansion through natural seedling establishment appears virtually impossible. (Seedlings are establishing to a limited extent within existing Abutilon menziesii stands, but survival potential is probably reduced by deer browsing.) It has been noted that the species is somewhat fire-tolerant (R. Hobdy, personal communication 1992). Since Abutilon menziesii may produce new

leaves only during a flush growth period in the wet season, defoliation by such pests as the Chinese rose beetle may have a significant negative impact on the survival of the species (USFWS 1986b). Carpenter bees and honey bees have been observed on the flowers, although honey bees seem to have difficulty accessing nectar because of the small size of the flowers. The native bee Nesoprosopis has rarely been observed on flowers of this species, and may have been more important as a pollinator in the past (R. Hobdy, personal communication 1992). A dual cycle of flowering has also been observed; some flowers open in early morning, staying open throughout the day and others open in the evening and remain open during the night. That may imply the past existence of a nocturnal pollinator, although no such pollinator has been observed (R. Hobdy, personal communication 1992). Seed dispersal agents, longevity of plants and seeds, specific environmental requirements, and other limiting factors are unknown.

C. Cyanea macrostegia ssp. gibsonii

Cyanea macrostegia ssp. gibsonii was seen flowering in the month of July (Rock 1919); however, details of its flowering period are not known. Pollination vectors, seed dispersal agents, longevity of plants and seeds, specific environmental requirements, and other limiting factors are unknown.

D. Cyrtandra munroi

Some work has been done on the reproductive biology of some Cyrtandra (Roelofs 1978, 1979), but not on that of Cyrtandra munroi specifically. The pollinators of these plants were not identified, although studies indicate that a pollinator, perhaps a specific pollinator, is necessary for successful pollination. Seed dispersal may be via birds that eat the fruits (Roelofs 1978). Flowering time, longevity of plants and seeds, specific environmental requirements, and other limiting factors are unknown.

E. Gahnia lanaiensis

July has been described as the "end of the flowering season" for Gahnia lanaiensis (Degener et al. 1964). Plants of this species have been observed with fruit in October (R. Hobdy, L. Loope, A. Medeiros, and P. Thomas, personal observation 1992). Pollination vectors, seed dispersal agents, longevity of plants

and seeds, specific environmental requirements, and other limiting factors are unknown.

F. Phyllostegia glabra var. lanaiensis

Flowering time, pollination vectors, seed dispersal agents, longevity of plants and seeds, specific environmental requirements, and other limiting factors are unknown.

G. Santalum freycinetianum var. lanaiense

The flowering period for Santalum freycinetianum var. lanaiense may be variable, usually in late summer or fall, with flowering frequent and fruiting occasional. Vegetative reproduction by root suckers has been noted infrequently in Maui populations (Medeiros et al. 1986). Observations of other species of Santalum indicate that flowering does not usually begin until plants are 3 years old and viable fruit is produced at about 5 years (Hamilton and Conrad 1990). Santalum freycinetianum var. lanaiense appears to flower and fruit readily, but rats eat the fruits before seeding occurs (USFWS 1986a). Birds are important seed dispersal agents for other sandalwoods (Hamilton and Conrad 1990); that may also be true for Santalum freycinetianum var. lanaiense. If seed is set and dispersed, the availability of suitable habitat for the seedlings may be a limiting factor (e.g. Medeiros et al. 1986). Historically the taxon may have preferred drier areas than those in which it is currently found, but these areas were the first to be destroyed. In addition, for successful growth of Santalum freycinetianum var. lanaiense, other plants or trees probably must grow nearby. Related species of Santalum are known to be hemiparasites and require the availability of the roots of other plants to maintain vigor during at least some growth stages, particularly young stages (Hamilton and Conrad 1990; R. Hobby, personal communication 1992). The specific requirements and preferences regarding these aspects of the life cycle of Santalum freycinetianum var. lanaiense are not known (Hamilton and Conrad 1990).

Growth of sandalwoods is generally slow. Girth increase for some species of sandalwood in natural conditions ranges from 1.0-1.3 centimeters (0.5 inch) per year. In areas where commercial sale of sandalwood is being explored, 50-100 years are required to grow a tree of "merchantable" size (Hamilton and Conrad 1990). Pollination vectors, seed dispersal agents,

longevity of plants and seeds, and other specific environmental requirements and limiting factors are unknown.

H. Tetramolopium remyi

Tetramolopium remyi flowers between April and January (Lowrey 1986). Field observations suggest that the population size of the species can be profoundly affected by variability in annual precipitation; the adult plants may succumb to prolonged drought, but apparently there is a seedbank in the soil that can replenish the population during favorable conditions (Lowrey 1986; T. Lowrey, personal communication 1992). Such seed banks are of great importance for arid-dwelling plants to allow populations to persist through adverse conditions. The aridity of the area, possibly coupled with human-induced changes in the habitat and subsequent lack of availability of suitable sites for seedling establishment, may be a factor limiting population growth and/or expansion. Requirements of this taxon in these areas are not known, but success in greenhouse cultivation of these plants with much higher water availability (T. Lowrey, personal communication 1992) implies that although these plants are drought-tolerant, perhaps the dry conditions in which they currently exist are not optimum. Individual plants are probably not long-lived (Lowrey 1986). Pollination is hypothesized to be possibly by butterflies, bees, or flies (Lowrey 1986). Seed dispersal agents, environmental requirements, and other limiting factors are unknown.

I. Viola lanaiensis

When approximately 21 plants were observed in October 1992 (R. Hobdy, L. Loope, A. Medeiros, and P. Thomas, personal observation 1992), one small fruit was noted; however, October may not have been the optimum time to observe flowering or fruiting. One sighting of this plant was on a relatively new landslide (HHP 1991); the rapid establishment of this taxon under these circumstances may reflect a high sensitivity to competition. Flowering time, pollination vectors, seed dispersal agents, longevity of plants and seeds, specific environmental requirements, and other limiting factors are unknown.

4. HABITAT DESCRIPTION

Observations regarding habitats of the Lana'i cluster taxa are presented here. In most cases, specific habitat requirements can only be deduced from observations at current known sites. In some cases the former range of the taxon is thought to have been much wider than at present (e.g. Santalum freycinetianum var. lanaiense, Tetramolopium remyi); therefore, recent habitat observations may not reflect optimum conditions.

The habitat of each of the Lana'i cluster taxa will be discussed individually. Capitalized community names used in this section are from Gagné and Cuddihy in Wagner et al. (1990).

A. Abutilon eremitopetalum

The habitat of Abutilon eremitopetalum is within the Lowland Dry Forest zone. The only known population is found at an elevation of 335 meters (1100 feet) on a moderately steep north-facing slope on Lana'i. The substrate is red sandy soil and rock. Historically, Abutilon eremitopetalum has been reported from elevations of 210-520 meters (690-1710 feet). Erythrina sandwicensis and Diospyros ferrea are the dominant trees in open forest of the area. Other associated native taxa include Canthium odoratum, Dodonaea viscosa, Nesoluma polynesianum, Rauvolfia sandwicensis, Sida fallax, and Wikstroemia sp. Associated alien plants include Lantana, Pluchea, and Leucaena.

B. Abutilon menziesii

On Lana'i, Abutilon menziesii occurs in psyllid-damaged stands of Leucaena leucocephala with an understory of Panicum maximum. The currently known habitat of Abutilon menziesii on Maui is gentle leeward slopes of summer-dry shrubland areas (part of the Lowland Dry Shrubland zone) with open to scattered closure and a substrate of rocky 'a'a (rough) lava or red soil, in communities usually dominated by alien plants. Abutilon menziesii has been reported from elevations of 150-425 meters (500-1400 feet). Associated species observed include the native Sida fallax, Dodonaea viscosa, and Waltheria indica as well as the alien Rhynchelytrum repens, Cenchrus ciliaris, Prosopis pallida, Lantana camara, Panicum maximum, Leucaena leucocephala, and Casuarina. All known populations of Abutilon menziesii are frequently exposed to severe drought and periodic flooding.

C. Cyanea macrostegia ssp. gibsonii

The habitat of Cyanea macrostegia ssp. gibsonii is the Lowland Wet Forest community. It has been observed to grow on flat to moderate or steep slopes, usually on lower gulch slopes or gulch bottoms, often at edges of streambanks, probably due to vulnerability to ungulate damage at more accessible locations. Sites are sunny to shady, mesic to wet with clay or other soil substrate. Cyanea macrostegia ssp. gibsonii has been reported from elevations of 760-970 meters (2490-3180 feet). Associated vegetation includes native ferns, shrubs, trees in wet Metrosideros forest or Diplopterygium-Metrosideros shrubland (sometimes with Dicranopteris), Perrottetia, Scaevola chamissoniana, Pipturus, Antidesma, Freycinetia, Psychotria, Cyrtandra, Dicranopteris, Broussaisia, Cheirodendron, Clermontia, Dubautia, Hedyotis, Ilex, Labordia, Melicope, Pneumatopteris, and Sadleria, and the alien Rubus rosifolius.

D. Cyrtandra munroi

The habitat of Cyrtandra munroi is Lowland Wet Forest (diverse, mixed mesic to wet Metrosideros forest), typically on rich, moist to wet, moderately steep talus slopes from 300 to 920 meters (980-3020 feet). It occurs on soil and rock substrates on slopes from watercourses in gulch bottoms and up the sides of gulch slopes to near ridgetops. Associated native species include, Diospyros, Metrosideros polymorpha, Hedyotis acuminata, Clermontia, Alyxia, Bobea, Coprosma, Dicranopteris, Freycinetia, Melicope, Myrsine, Perrottetia, Pipturus, Pittosporum, Pleomele, Pouteria, Pneumatopteris, Psychotria, Sadleria, Scaevola, Xylosma, and other Cyrtandra. In addition, strawberry guava (Psidium cattleianum) was present at most sites on a site visit in 1991 (J. Lau, personal communication 1992).

E. Gahnia lanaiensis

The habitat of Gahnia lanaiensis is Lowland Wet Forest (shrubby rainforest to open scrubby fog belt or degraded lowland mesic forest). It occurs on flat to gentle ridgecrest topography in moist to wet clay or other soil substrate at elevations of approximately 940-1,030 meters (3,080-3,380 feet) in open areas or in moderate shade. Associated species include native mat ferns, shrubs, and trees (Metrosideros, Dicranopteris, and Diplopterygium shrubland with Sadleria, Coprosma, Lycopodium, Scaevola, and

Styphelia) as well as alien species (e.g. Leptospermum scoparium, Myrica faya, and Psidium cattleianum).

F. Phyllostegia glabra var. lanaiensis

The habitat of Phyllostegia glabra var. lanaiensis is Lowland Wet Forest. It has been observed in the same habitat as Cyanea macrostegia ssp. gibsonii in mesic to wet forest in gulch bottoms and sides, often in quite steep areas.

G. Santalum freycinetianum var. lanaiense

The habitat of Santalum freycinetianum var. lanaiense is quite diverse, including Lowland Dry Forest on well-drained barren soils to Mesic Forest on shallow soils at higher elevations. The areas it now occupies have been severely degraded by grazing and browsing of livestock, and continue to be degraded by the grazing of exotic game animals. Much of the native vegetation has been removed by these activities, increasing wind erosion of the fragile soils. Santalum freycinetianum var. lanaiense has been observed in mostly mesic, sometimes wet, areas of level to gentle slope with deep soil; on mesic, moderate to steep, lower to upper gulch slopes and ridgecrests in mixed native shrubland grading to forest; in xeric to wet forest and shrublands; and in Nestegis/Diospyros lowland dry forest with dense growth of Melinis and Lantana. Historically the taxon may have preferred drier areas than those in which it is currently found, but these areas were the first to be destroyed.

H. Tetramolopium remyi

The habitat of Tetramolopium remyi is Lowland Dry Shrubland on dry, exposed ridges or flats. Its elevational range has historically been 150-770 meters (500-2500 feet). The only known extant population occurs at about 200 meters (660 feet) elevation on nearly barren red lateritic soils in a highly overgrazed area in Dodonaea viscosa-Heteropogon contortus shrubland. Associated native species include Bidens mauiensis, Bidens menziesii, Eragrostis grandis, Lipochaeta heterophylla, and Waltheria indica. Associated alien species include Lantana camara, Pennisetum setaceum, and Acacia farnesiana.

I. Viola lanaiensis

The habitat of Viola lanaiensis is Lowland Wet Forest or lowland mesic shrubland. It has been observed on moderate to

steep slopes from lower gulches to ridgetops from 670-975 meters (2200-3200 feet) elevation in mesic to wet areas, with a soil and decomposed rock substrate in open to shaded areas; it was once observed growing from crevices in drier soil on a mostly open rock area near a recent landslide. Associated vegetation includes ferns and short windswept shrubs or other diverse mesic community members such as Metrosideros polymorpha, Scaevola chamissoniana, Hedyotis terminalis, Hedyotis centranthoides, Styphelia, Carex, Ilex, Psychotria, Antidesma, Coprosma, Freycinetia, Myrsine, Nestegis, Psychotria, and Xylosma.

Several other Endangered, Threatened, Proposed or Candidate plants occur in the same areas where the Lana'i cluster taxa are now found, or in similar habitat, which may be managed for the recovery of the Lana'i cluster taxa in the future. These taxa are summarized in Table 1.

5. CURRENT AND HISTORIC RANGE AND POPULATION STATUS

The historic and current ranges of each of the Lana'i cluster taxa, as well as the population status of each, will be discussed individually. Maps or descriptions of the exact locations of known individuals will not be included in this Plan due to the possibility that vandalization or unauthorized collection could be encouraged by the public release of this information. The U.S. Fish and Wildlife Service will consider requests for Appendix B, which contains site specific maps, on a case-by-case basis.

For the purposes of this plan, the term "site" is defined as a discrete area containing individuals of any of the nine species covered in this plan, and is used primarily to delineate areas that will be managed as a unit. The term "population" is defined as a reproductively separate group of individuals of a single species. Therefore, a site may contain a single population of a single species, several populations of a single species, or several populations of several species.

Table 1. Endangered, Threatened, Proposed and Candidate species found in the habitat of the Lana'i cluster taxa.

<u>Species</u>	<u>Status</u>
Acacia koaia	Species of Concern
Caesalpinia kavaiensis	Endangered ¹
Canavalia pubescens	Species of Concern
Capparis sandwichiana	Species of Concern
Centaureium sebaeoides	Endangered ²
Ctenitis squamigera	Endangered ³
Cyanea grimesiana ssp. grimesiana	Species of Concern
Cyperus trachysanthos	Species of Concern
Cyrtandra lydgatei	Species of Concern
Exocarpos gaudichaudii	Species of Concern
Gardenia brighamii	Endangered ⁴
Hedyotis mannii	Endangered ⁵
Hedyotis schlechtendahlia var. remyi	Species of Concern
Hibiscus brackenridgei ssp. brackenridgei	Endangered ⁶
Mariscus fauriei	Endangered ⁷
Melicope munroi	Species of Concern
Portulaca molokiniensis	Species of Concern
Portulaca villosa	Species of Concern
Schiedea menziesii	Species of Concern
Sesbania tomentosa	Endangered ⁶
Spermolepis hawaiiensis	Endangered ⁶
Tetramolopium lepidotum ssp. lepidotum	Endangered ²
Vigna owahuensis	Endangered ⁶
Wikstroemia bicornuta	Species of Concern
Zanthoxylum hawaiiense	Endangered ⁷

Proposed = Taxa has been officially proposed for listing
 Species of Concern = Species for which the Service seeks additional information. These taxa are not candidates for Federal listing.

1 = Recovery is addressed in the Caesalpinia kavaiensis and Kokia drynarioides Recovery Plan

2 = Recovery is addressed in the Waianae Plant Cluster Recovery Plan

3 = Recovery will be addressed in the Hawaiian Ferns Recovery Plan

4 = Recovery is addressed in the Gardenia brighamii Recovery Plan

5 = Recovery will be addressed in the Molokai Plant Cluster Recovery Plan

6 = Recovery will be addressed in the Multi-Island Plant Cluster Recovery Plan

7 = Recovery will be addressed in the Big Island Plant Cluster Recovery Plan

A. Abutilon eremitopetalum - Recovery Priority # 2 (on the USFWS 1-18 scale, see Appendix C)

Abutilon eremitopetalum is endemic to dry forest habitats of Lana'i. Since its discovery in the 1930s, it has always been very

rare and has been known only in small, widely scattered colonies. It has been recorded across the northern slope of the island from Ka'a (NW), Mahana, Maunalei, Kalulu, and Pawili (NE) in the dryland forest zone (210-520 meters [690-1710 feet]). Individuals of Abutilon eremitopetalum (at least some from Kalulu) were introduced to the dry forest area of Kanepu'u by G.C. Munro in the 1920s-1930s and may have grown there in a naturalized state. In 1930, reproducing populations were found in the Maunalei area, but only two or three plants were found there in 1951. By the early 1980s, the taxon was generally considered extinct (Wagner et al. 1985).

About 60-70 plants were discovered in 1987 on a slope in Kahea Gulch (north fork) at elevations of between 240-320 meters (790-1050 feet) (Steve Perlman, National Tropical Botanical Garden (NTBG), Hawai'i Plant Conservation Center (HPCC), herbarium specimen #6405, Bernice P. Bishop Museum, Honolulu, Hawai'i). In June 1989, Joel Lau observed approximately 70 plants in this same population (Joel Lau, The Nature Conservancy of Hawai'i, Hawai'i Heritage Program (TNCH), personal communication 1992). In 1990, Steve Perlman observed 30 plants in this population, some with flowers and/or fruit, but by June 1993, all but 7 had been killed by deer (S. Perlman, personal communication 1993). The current range of Abutilon eremitopetalum is illustrated by Figure 9 and Appendix B.

B. Abutilon menziesii - Recovery Priority # 2

Abutilon menziesii has apparently been uncommon since its discovery in the 1800s. It once occurred locally in dryland forest habitats on the islands of Lana'i, Maui, Hawai'i, and possibly O'ahu.

Historic locations on Lana'i include Malauea & Kapo, west and northwest of Pu'u Mahanalua, Mahana, Manele, Maluaea, Kapo, and near Palikaholo. Of these, Pu'u Mahanalua ("Twin Peaks") is the only site known to have surviving plants. In 1990, 50-100 plants were observed there with flowers and fruits (HPCC #905212), and about 33 plants were observed nearby at an elevation of 370 meters (1200 feet) (HPCC #905213). There are an estimated 200

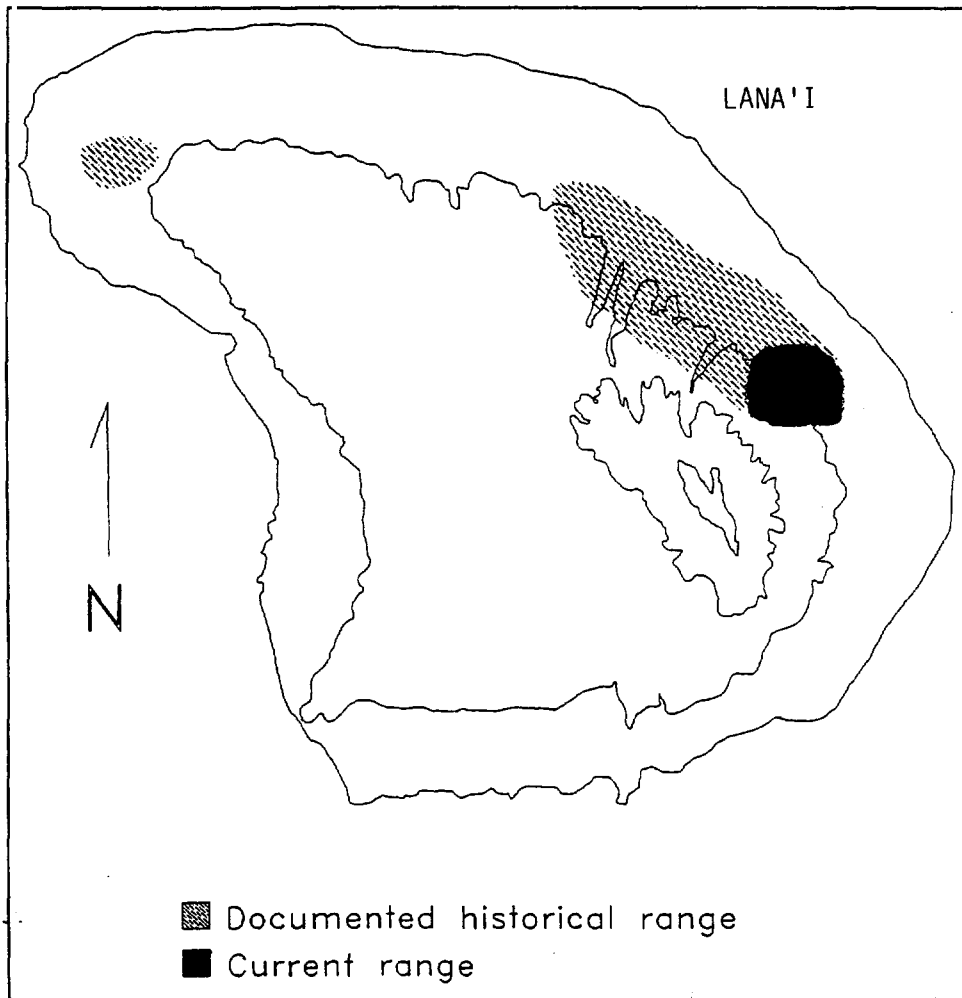


Figure 9. Current and historical range of Abutilon eremitopetalum.

scattered plants in this population (R. Hobdy, personal communication 1992). These plants are generally 1-3 meters (3.3 to 9.8 feet) tall. In 1991, a second site containing 3 populations of scattered Abutilon menziesii totalling

approximately 400 plants was reported by Robert Hobdy (based on information from Sol Kaho'ohalahala, a Lana'i resident) at an elevation of approximately 320-350 meters (1050-1150 feet) in an area north of Kaumalapau Road (on land formerly grazed by cattle) in psyllid-damaged stands of Leucaena leucocephala with an understory of Panicum maximum (R. Hobdy, personal communication 1992; Lloyd L. Loope, Arthur C. Medieros, and Philip A. Thomas, Haleakala National Park, personal observations 1992).

Five known sites with single small populations of Abutilon menziesii (totalling approximately 45 individuals) survive on Maui, 3 are on red soils in the Kalialinui Gulch drainage at elevations of 210-230 meters (690-750 feet) near Pukalani and two are on 'a'a lava at elevations of 150-425 meters (500-1400 feet) on lava flows in the vicinity of Pu'u o Kali near Kihei. In 1990, 2 to 3 clumps of this species (totalling 12 or fewer plants) were observed by Steve Perlman at an elevation of 350 meters (1150 feet) at Pu'u o Kali (HPCC #905188). All Maui populations are subject to grazing. No conservation measures are being taken for these populations.

Abutilon menziesii was once believed extirpated from the island of Hawai'i (USFWS 1986b), but was rediscovered recently at Puakō, Hawai'i. This population is on private property; efforts by the landowner are currently being made to facilitate the protection of this population (Evangeline Funk, personal communication 1992).

A single plant of Abutilon menziesii was reported from Barbers Point, O'ahu in 1981; this plant may have been an escapee from cultivation (Char and Balakrishnan 1979). At that time all cultivated plants were descended from a population in Puakō on the island of Hawai'i (Bates in Wagner et al. 1990). However, this plant may represent a natural occurrence (Char and Balakrishnan 1979). R. Hobdy, (personal communication 1992) feels that, due to differences in leaf morphology of progeny from this plant as compared with other populations, it is likely that it did, in fact, represent a separate natural population. The current status of this plant is unknown, but it is assumed to be gone. The area in which it formerly occurred was subject to development at the time the plant was last sighted (USFWS 1986b). The current range of Abutilon menziesii is illustrated by Figure 10.

Abutilon menziesii is reportedly available for sale from three commercial nurseries in the state of Hawai'i (HPCC 1992). Plants reportedly thrive and bloom regularly under nursery

conditions and propagation by seed is successful (Kenneth Boche, Aikane Nursery, Kapa'au, Hawai'i, personal communication 1992; Anna Palomino, personal communication 1992). Cuttings are also successful; cultivation requirements are similar to those of Hibiscus (K. Boche, personal communication 1992). Also, this species has reportedly been planted at Kalōpa State Park on the island of Hawai'i (K. Boche, personal communication 1992). Plants from Hawai'i, Lana'i, Maui, and O'ahu are now each represented in at least one cultivated situation (Bates in Wagner et al. 1990; R. Hobdy, personal communication 1992).

C. Cyanea macrostegia ssp. gibsonii - Recovery Priority # 6

Cyanea macrostegia ssp. gibsonii is historically documented from the summit of Lana'ihale and wet forest in the upper parts of the Mahana, Kaiholena, and Maunalei drainages of Lana'i at elevations between 760-970 meters (2490-3180 feet) (Rock 1919, Lammers in Wagner et al. 1990). In 1989, only a single plant could be found at one site in Kaiholena Valley, and it was being overgrown by kahili ginger (Hedychium gardnerianum) (R. Hobdy, personal communication 1992). A recent survey by the Hawai'i Heritage Program of TNCH provided virtually the only information on current populations. Populations of Cyanea macrostegia ssp. gibsonii occur on Lana'i in two gulches in upper Kaiholena Valley, two feeder gulches into Maunalei Valley, and four sites near the Lana'ihale summit. In the Maunalei Valley feeder gulches, the survey located two populations with a total of four mature plants and two juveniles. In the upper Kaiholena Valley, one mature plant and five seedlings were seen in Waialala Gulch; and 10 mature plants were seen in the gulch between Kunoa and Waialala Gulches. The populations near the Lana'ihale summit include 1 population in which 42 individuals (34 mature, 8 juvenile) were counted and 3 populations with a total of 8 mature plants and 1 juvenile. The known surviving individuals of the taxon thus comprise 8 populations totalling approximately 75-80 plants (Hawai'i Heritage Program [HHP] 1991). The current range of Cyanea macrostegia ssp. gibsonii is illustrated by Figure 11 and Appendix B.

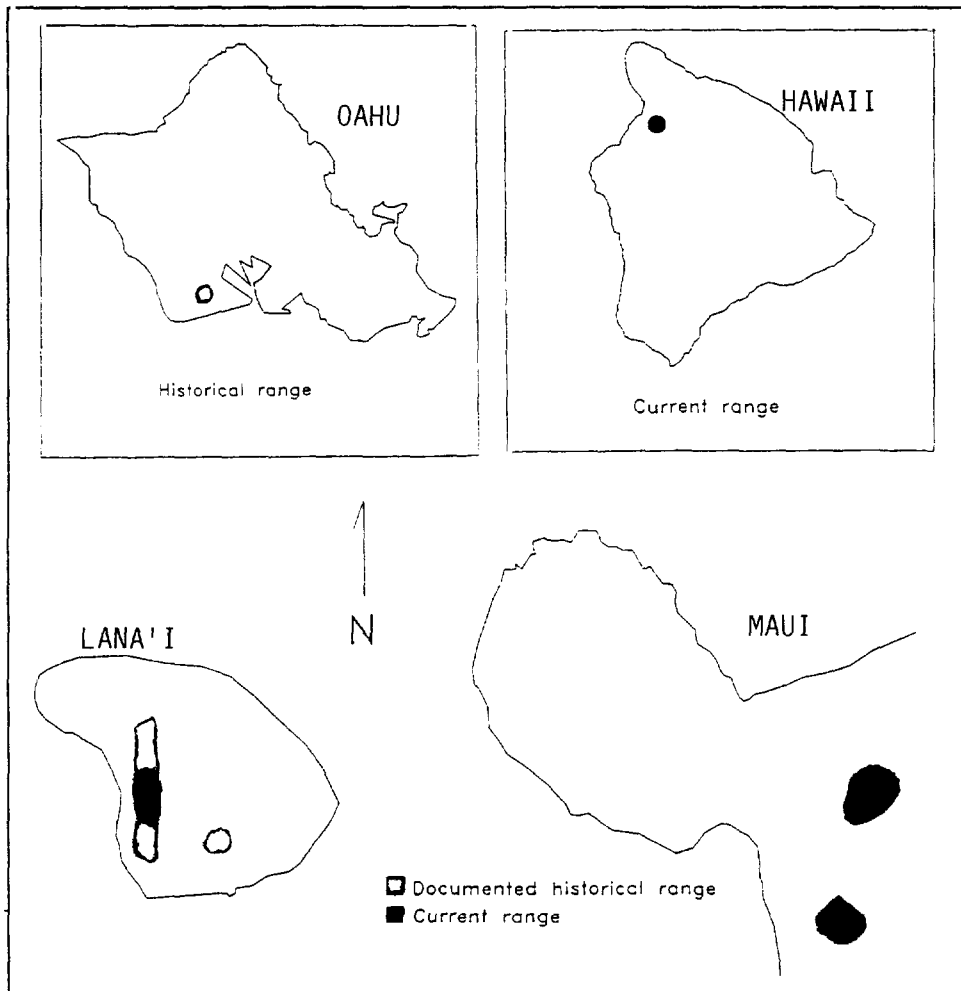


Figure 10. Current and historical range of *Abutilon menziesii*.

D. Cyrtandra munroi - Recovery Priority # 5

Historically, Cyrtandra munroi was known from scattered collections from wet forest on Lana'ihale on Lana'i (probably 910-920 meters (2980-3020 feet)) and from Makamaka'ole Gulch on West Maui (Wagner et al. 1990).

In 1991, J. Lau found six populations of Cyrtandra munroi on Lana'i. Five small populations totalling 16 individuals were found in mesic to wet forest habitat in the upper elevations (840-895 meters (2760-2940 feet)) of the Waiapa'a and Kapohaku drainages, and a single plant was seen at 750 meters (2460 feet) elevation in the Maunalei drainage in the gulch between Kunoa and Waialala Gulches; strawberry guava (Psidium cattleianum) was present at most of these sites (HHP 1991).

Cyrtandra munroi was considered common in the Makamaka'ole area on State land in 1971, and 30+ plants were seen in that location in 1993 (Ken Wood, NTB, personal communication 1993). One Cyrtandra grayana individual, discovered in 1989 in privately owned Honolulu Valley, about 8 kilometers (5 miles) from the Makamaka'ole population, was erroneously included in the listing package (Herbst et al. 1992) as Cyrtandra munroi (Joan Yoshioka, TNC, personal communication 1993), and so is not addressed in this plan. The current range of Cyrtandra munroi is illustrated by Figure 12 and Appendix B.

E. Gahnia lanaiensis - Recovery Priority # 5

Gahnia lanaiensis is endemic to Lana'i. Currently, fewer than 50 large plants in 4 populations in wet forest along the summit ridges of Lana'ihale at 915-1033 meters (3,000 - 3,400 feet) elevation are known (HHP 1991). This distribution encompasses the entire known historic range of the species. Seeds were collected by S. Perlman from all four known populations in 1991 (HPCC #s 915225,26,28,32). The current range of Gahnia lanaiensis is illustrated by Figure 13 and Appendix B.

F. Phyllostegia glabra var. lanaiensis - Recovery Priority # 6

Phyllostegia glabra var. lanaiensis is known only from two collections from Lana'i (one near Kaiholena) and was last collected in 1914 (two fertile specimens). A report of this plant

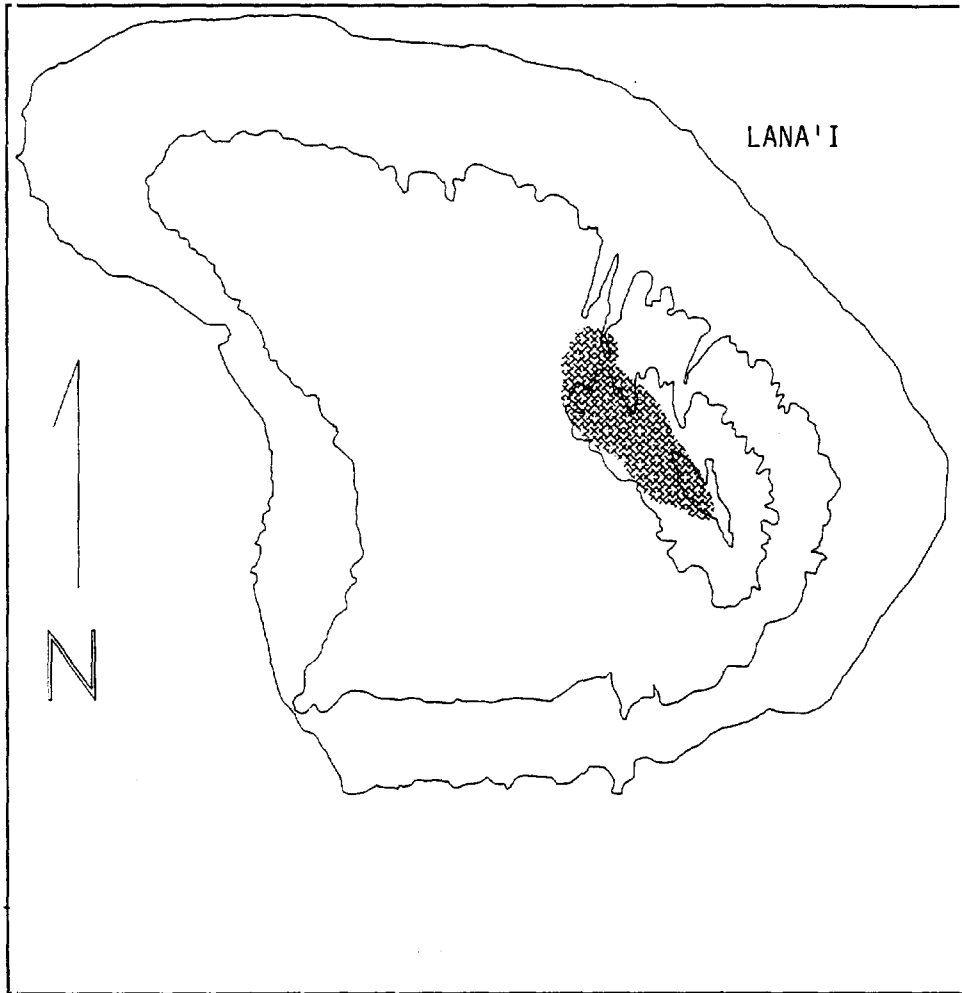


Figure 11. Current and historical range (identical) of Cyanea macrostegia ssp. gibsonii.

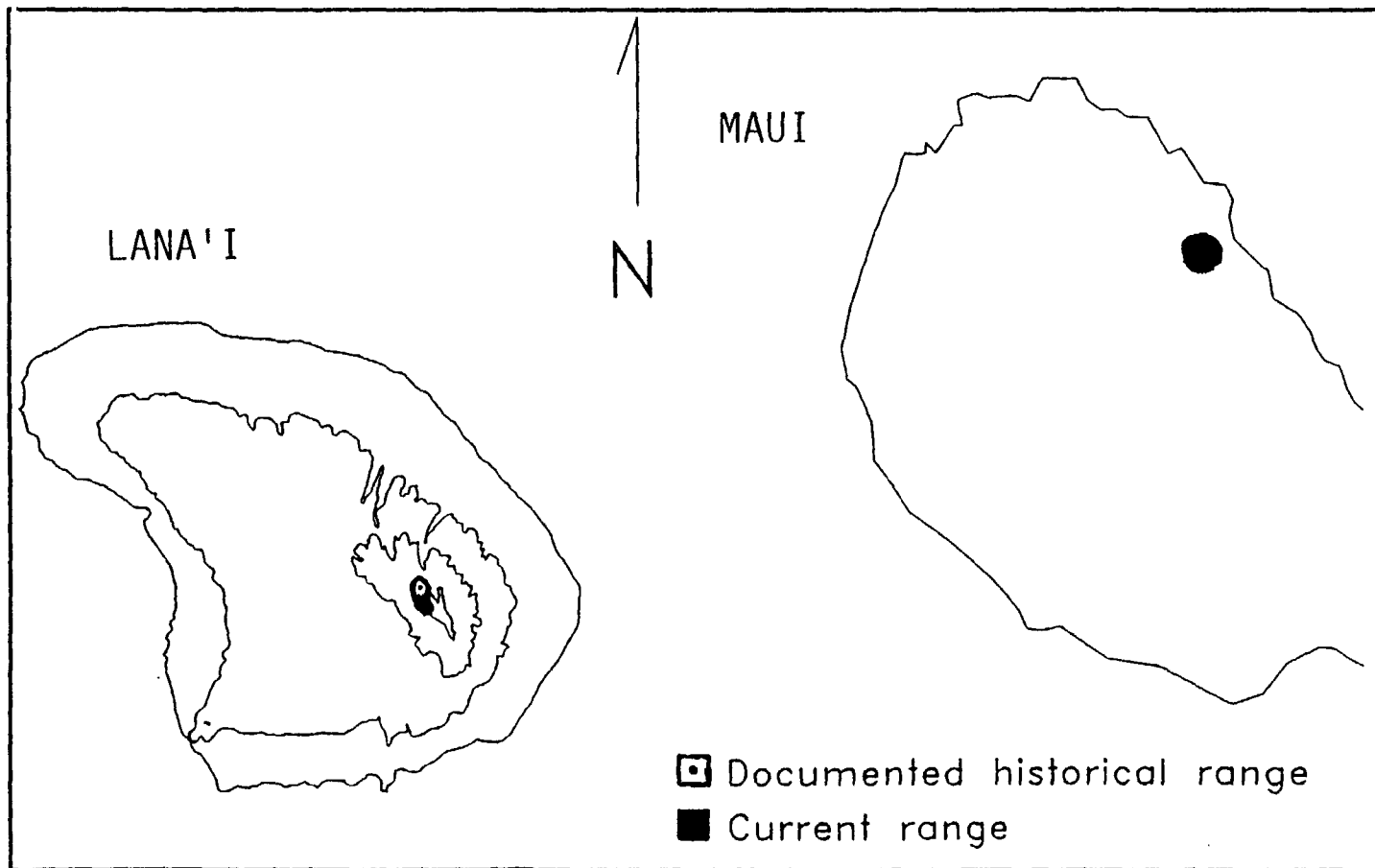


Figure 12. Current and historical range of Cyrtandra munroi.

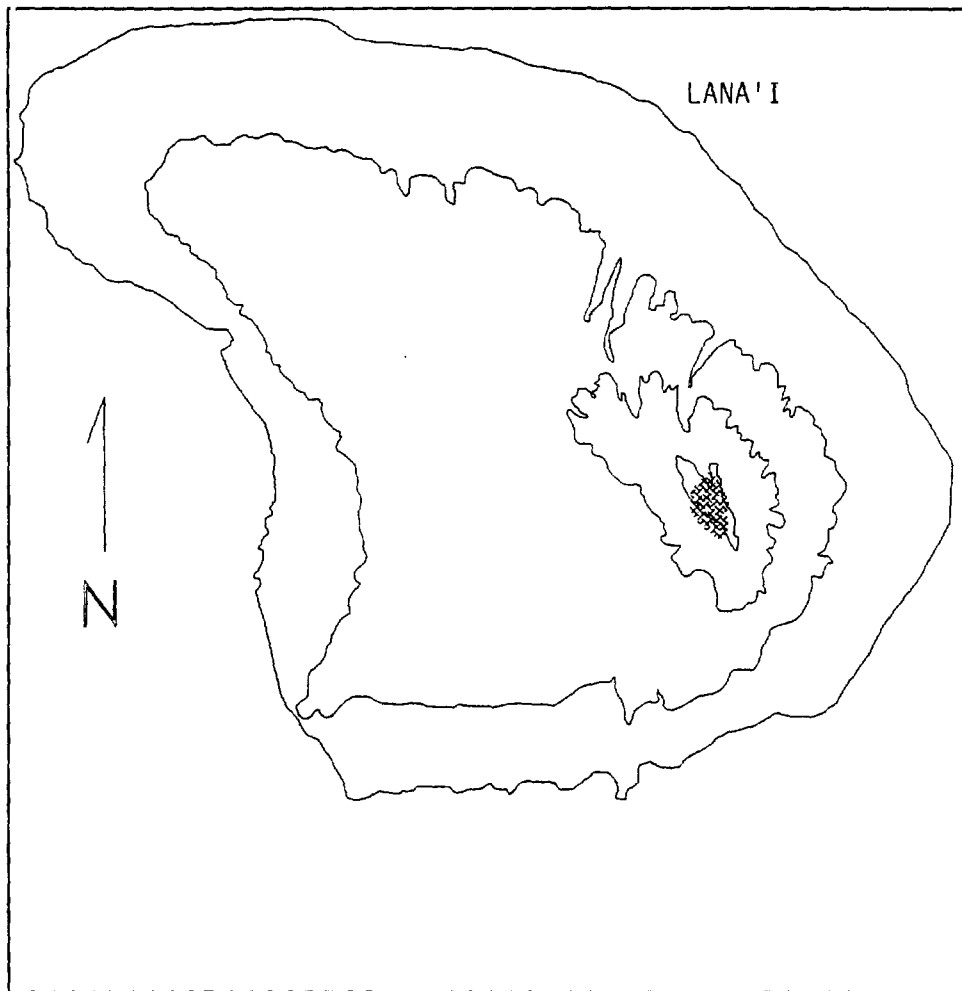


Figure 13. Current and historical range (identical) of Gahnia lanaiensis.

from the early 1980s probably was erroneous and should be referred to as Phyllostegia glabra var. glabra (R. Hobdy, personal communication 1992). Since the gulches and valleys of Lana'ihale are rugged and steep and are only very rarely explored by

botanists, there is hope that this taxon still exists. Finding it is made much more difficult by taxonomic confusion with the uncommon sympatric Phyllostegia glabra var. glabra, especially since flowers are needed for a definitive determination. The probable current range of Phyllostegia glabra var. lanaiensis is illustrated by Figure 14 and Appendix B.

G. Santalum freycinetianum var. lanaiense - Recovery Priority # 3

This plant is known from Kanepu'u and the summit ridge system of the island of Lana'i and, as the taxon is defined in Wagner et al. (1990), populations that occur at scattered locations on Maui. Prior to its discovery by the scientific community, the range of Santalum freycinetianum var. lanaiense may have been considerably reduced by Hawai'i's highly profitable sandalwood trade. This industry began around 1800, peaking between 1810 and 1820, and not ending until around 1840 by which time the forests were exhausted (Degener 1930, Merlin and VanRavenswaay in Hamilton and Conrad 1990).

Currently, Santalum freycinetianum var. lanaiense occurs on Lana'i in widely scattered locations in a very wide range of habitats, including dryland forest at Kanepu'u and in mesic to wet forest on Lana'ihale (e.g. Rock 1916, HHP 1991). This sandalwood taxon also occurs on leeward East and West Maui. About 20 individuals occur on the southern slope of Haleakala in a band from 1615-1980 meters (5300-6500 feet). These individuals occur singly on rocky outcrops where goats cannot reach them. As many as a few hundred individuals remain on leeward W. Maui, also in extremely inaccessible locations, between 914 and 1370 meters (3000 and 4500 feet). Existing information is not sufficient to determine how many populations are represented by these Maui individuals (R. Hobdy, personal communication 1994). A survey on Lana'ihale (wet and mesic habitats) in 1991 by J. Lau found 55 sandalwood plants (2-5 meters (6-16 feet) tall) in 13 widely scattered populations (HHP 1991). No more than 20 individuals--perhaps as few as 3 to 6--occur in the population in the dryland habitats of the Kanepu'u area, for a total of 14 populations on Lana'i (Peter Connally, Haleakala National Park, personal observation 1992; R. Hobdy, personal communication 1993); The current range of Santalum freycinetianum var. lanaiense is illustrated by Figure 15 and Appendix B.

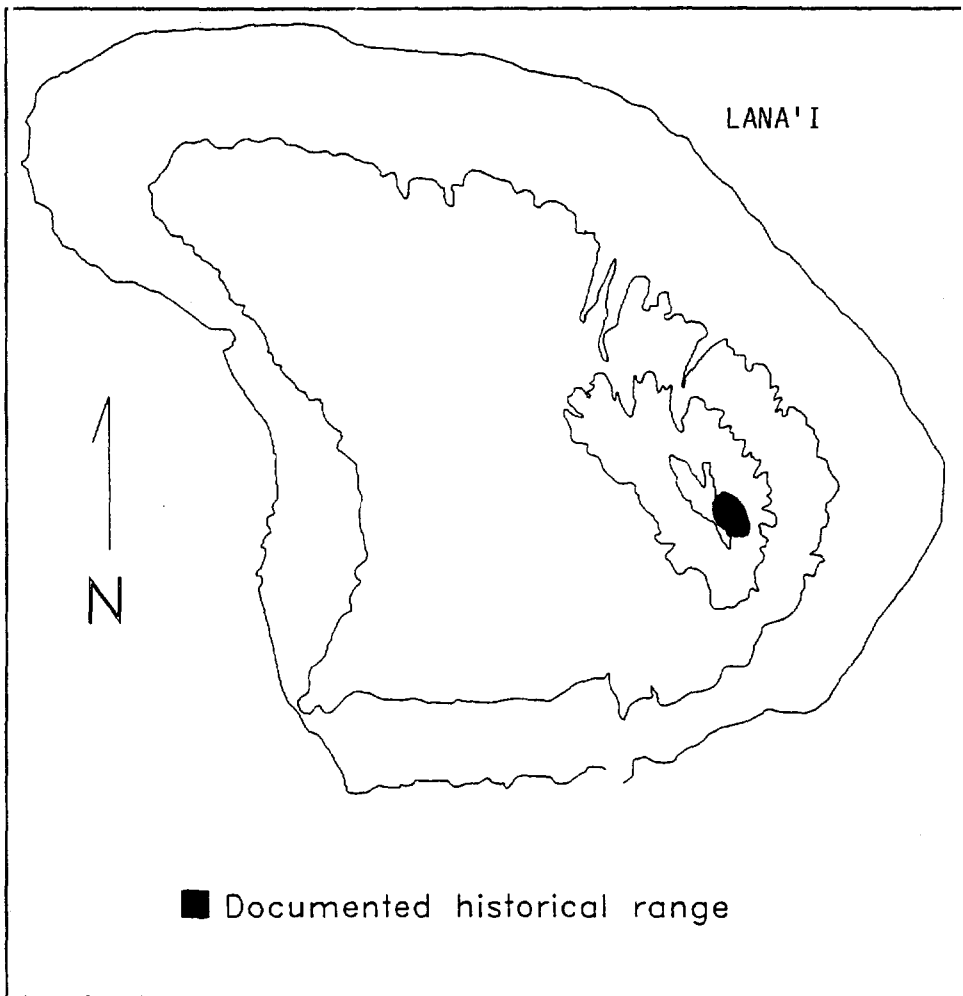


Figure 14. Historical (and probably current) range of Phyllostegia glabra var. lanaiensis.

Historically, Santalum freycinetianum var. lanaiense may have preferred drier areas than those in which it is currently found, but these areas were the first to be destroyed. The areas it now occupies have been severely degraded by grazing and browsing of livestock, and continue to be degraded by the grazing of exotic game animals. Much of the native vegetation has been removed by these activities, increasing wind erosion of the fragile soils. Harold St. John (1947) suggested that the present range of sandalwood reflects only the upper portion of its former range; he believed that sandalwoods were once common, if not abundant, throughout the Hawaiian lowlands. The recent decline in numbers of the species is largely due to loss of habitat.

H. Tetramolopium remyi - Recovery Priority # 2

Tetramolopium remyi has been collected in the past in widely scattered localities on dry ridges of Lana'i at elevations between 100-250 meters (330-820 feet). Today, there is only one known population of Tetramolopium remyi that consisted of six individuals as of July 1992 (Timothy Lowrey, University of New Mexico, personal communication 1992) and seven individuals as of 21 October 1992 (R. Hobdy, L. Loope, A. Medeiros, and P. Thomas, personal observation 1992). As of May 21, 1993, deer had eaten all adults and all but two seedlings (S. Perlman, personal observation 1993). The population is, or was, in an area of about 230 square meters (2475 square feet) in dry shrubland on the north side of Aualua Ridge at approximately 220 meters (720 feet) elevation (Wagner et al. 1990; HPCC #905214; T. Lowrey, personal communication 1992). Fluctuations (from 6 to 100 to 6 individuals from 1978 to 1992) in population size of Tetramolopium remyi are normal depending on season and rainfall and a substantial seed bank may exist in the vicinity of the population (Lowrey 1986; R. Hobdy, personal communication 1992; T. Lowrey, personal communication 1992). Since the plants are not conspicuous and the area is not regularly explored by botanists, there is clearly a possibility that additional Lana'i populations exist.

Historically, Tetramolopium remyi was also known from dry exposed ridges or flats and in the foothills of southern West Maui

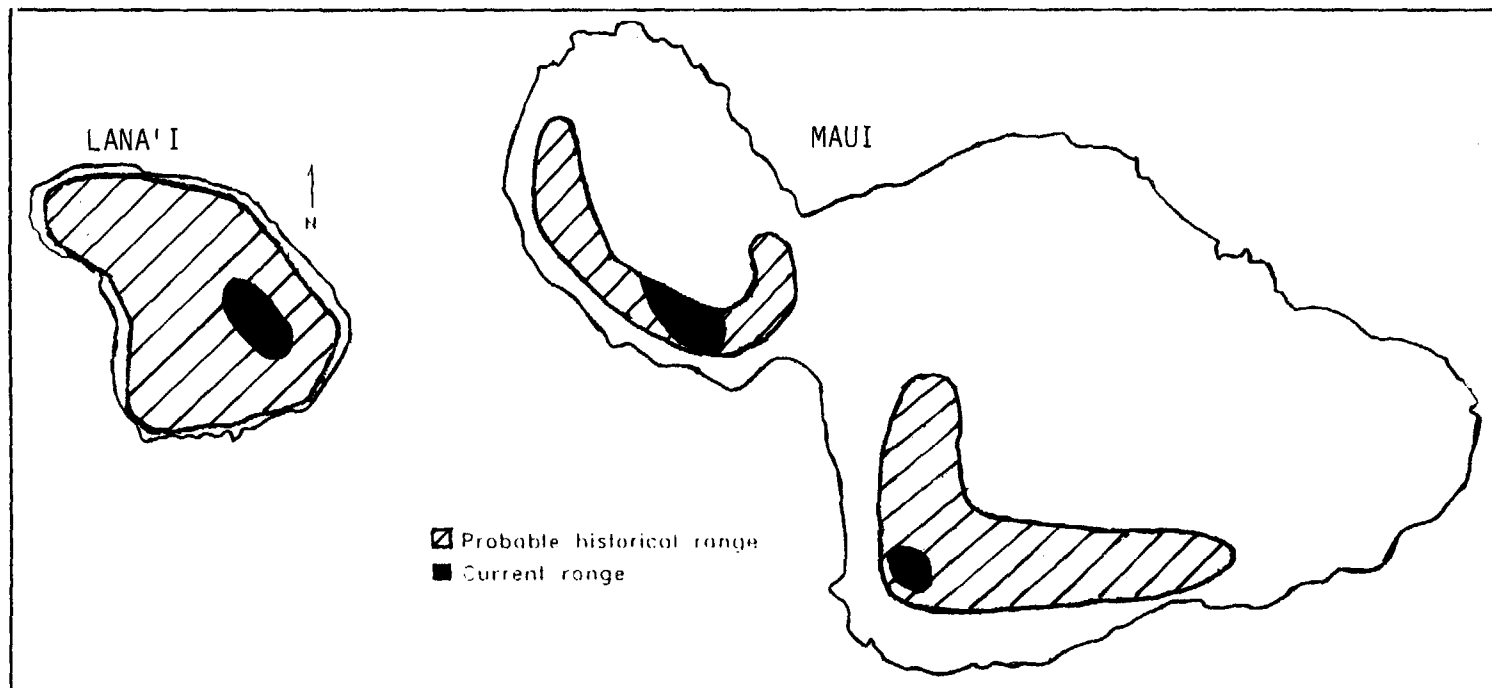


Figure 15. Current and historical range of *Santalum freycinetianum* var. *lanaiense*.

above Ma'alaea Bay (Wagner et al. 1990). It has not been documented from Maui since 1944, and is probably extirpated from that island (USFWS 1991, Lowrey in Wagner et al. 1990). The current range of Tetramolopium remyi is illustrated by Figure 16 and Appendix B.

I. Viola lanaiensis - Recovery Priority # 2

Viola lanaiensis was first collected by Remy sometime between 1851 and 1855 (USFWS 1991). It was known historically from scattered sites on the summit, ridges, and upper slopes of Lana'ihale (from near the head of Kaiolena and Ho'okio Gulches to the vicinity of Ha'alelepa'akai, a distance of about 4 kilometers [2.5 miles]) at elevations of approximately 850-975 meters (2790-3200 feet) (USFWS 1991, Wagner et al. 1990, St. John 1989). Its habitat is wet or mesic forest or shrubland.

An occurrence of Viola lanaiensis was known in the late 1970s along the summit road near the head of Waialala Gulch where a population of approximately 20 individuals flourished. That population has since disappeared due to habitat disturbance (R. Hobby, personal communication 1992).

Three small populations are currently known, totalling fewer than 80 individuals. One population is located in Kunoa Gulch at an elevation of 810 meters (2660 feet); another is in the adjacent gulch to the northwest (between Kunoa and Waialala Gulches) at approximately 800 meters (2620 feet). The largest population (approximately 38 individuals) is in the extreme upper end of the northernmost drainage of Awehi Gulch just below Waiakeakua and south of Puhielelu Ridge (HHP 1991). A total of 26 individuals was seen in the vicinity of the Awehi Gulch population, within a very restricted area, during a site visit on 20 October 1992 (R. Hobby, L. Loope, A. Medeiros, and P. Thomas, personal observation 1992). The current range of Viola lanaiensis is illustrated by Figure 17 and Appendix B.

6. REASONS FOR DECLINE AND CURRENT THREATS

Reasons for decline

The primary reason for the decline of all taxa treated here is habitat alteration by humans, either directly (e.g. conversion of habitat to agricultural use) or indirectly (e.g. introduction of exotic species, erosion).

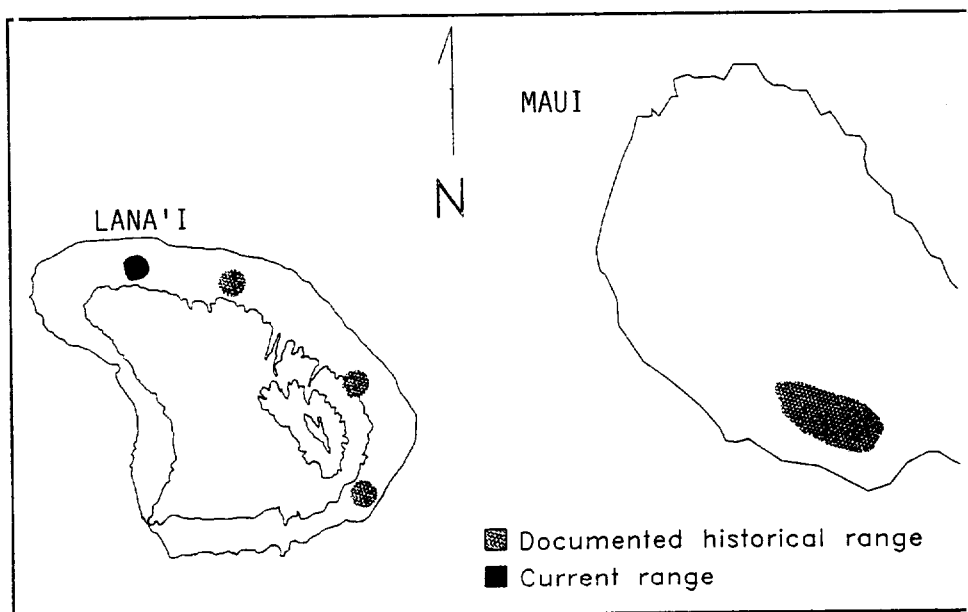


Figure 16. Current and historical range of Tetramolopium remyi.

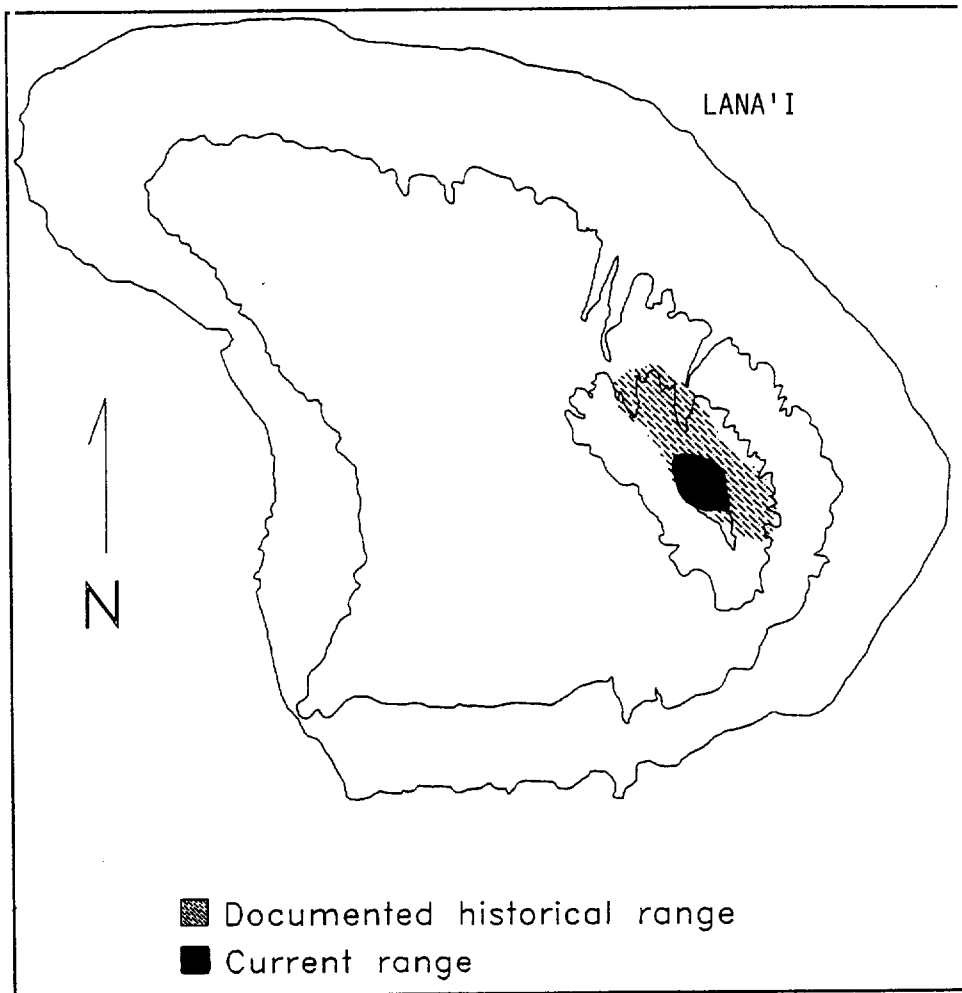


Figure 17. Current and historical range of *Viola lanaiensis*.

Surviving remnants of native vegetation on Lana'i provide evidence that prior to the arrival of Polynesian colonizers, the island was covered throughout by forests and shrublands. Polynesian agriculture and fire undoubtedly significantly modified the island's vegetation. The rate of modification accelerated after arrival of Europeans with the ranching of cattle and sheep, the clearing of land for pineapple and sugar cane cultivation, feralization of domestic animals such as goats, cattle, and pigs, and the introduction of game animals such as axis deer and mouflon (Ovis musimon) (Cuddihy and Stone 1990, Fosberg 1936a, Tomich 1986).

Much of the dryland ecosystem of Lana'i, the habitat of Abutilon eremitopetalum, Abutilon menziesii, and Tetramolopium remyi, was long ago cleared for cultivation or pasture. Erosion has long been and continues to be a threat to virtually all the taxa treated in this plan, as have fire and drought. Weedy alien plants have been introduced intentionally or accidentally to the Hawaiian Islands, and crowd and outcompete native plants as well as create fire hazards. These weeds have had serious adverse effects on the ecosystems of the Lana'i cluster taxa.

Cattle, sheep, goats, and pigs were eventually eliminated from the island; however, axis deer and mouflon are still numerous and present serious threats to the Lana'i cluster taxa. Only about 10% or less of the island presently remains in native forest or shrubland.

Current threats

Current threats to all the Lana'i cluster taxa include alien plants, alien insects, alien mammals, and habitat alteration for development or agriculture. Additional factors threaten certain individual taxa; these are detailed here.

A. Alien Plants

An increasing number of invasive alien plant species are encroaching on the habitats of the rare plant taxa of Lana'i. Strawberry guava (Psidium cattleianum) is particularly dominant on the northwestern side of Lana'ihale, and is becoming common elsewhere. Firetree (Myrica faya) is spreading rapidly from the southern end, and manuka (Leptospermum scoparium) has spread from

the east side to become widespread throughout much of the area. Kahili ginger (Hedychium gardnerianum) often occupies valley floors, while koa haole (Leucaena leucocephala), lantana (Lantana camara), and sourbush (Pluchea symphytifolia) are ubiquitous aggressive invaders. These weedy plants generally compete more successfully than the native plant species for water, minerals, space, and light. They tend to displace the natives through shading of established plants and preventing reproduction. Tibouchina (Tibouchina herbacea), an invasive melastome, is just beginning to invade Lana'i. It is likely to become a major invader in moist habitats of upper Lana'ihale. In drier areas, broomsedge (Andropogon virginicus), mollasses grass (Melinis minutiflora) and Guinea grass (Panicum maximum) are dominant alien invaders. These two species compete with native plants such as Tetramolopium remyi. They also provide a major source of fuel, increasing the potential threat of fire in areas where they occur. Also in drier areas, Christmasberry (Schinus terebinthifolius) is a major invader of native habitat. There is an added threat from new alien species becoming established on the island, partly as a result of increased commerce and changes in land use. For example, fountain grass (Pennisetum setaceum) was first detected on Lana'i in June of 1992 (Adams 1992). If fountain grass were to become widely established, it would significantly exacerbate the fire problem. Kikuyu grass (Pennisetum clandestinum) is also present on Lana'i; this grass creates dense monospecific mats inhibiting reproduction of all other species.

Individual species accounts:

1. Broomsedge (Andropogon virginicus). This perennial bunchgrass, native to the southeastern U.S., commonly forms continuous cover in boggy, open, mesic and dry habitats in Hawai'i. It releases highly persistent allelopathic substances (Rice 1972). (Allelopathic substances are plant products released into the soil that inhibit the germination and/or growth of other plant species.) Dead broomsedge provides excellent fuel for fires. This grass is fire-stimulated; its cover increases dramatically with each fire (Smith 1985). In areas where it occurs, both fire intensities and acreage burned have increased. Growth of broomsedge is asynchronous with Hawai'i's climatic pattern;

the species is dormant during the rainy season, which Mueller-Dombois (1973) has shown leads to increased erosion in some areas.

2. Molasses grass (Melinis minutiflora). Diverse sites such as dry mountain ridges and mesic to wet forests of Lana'i, like many areas of the Hawaiian Islands, are being invaded by molasses grass. This African grass produces a dense mat capable of smothering plants, provides fuel for fire, and carries fire into areas with vulnerable native plants. In Hawai'i Volcanoes National Park, molasses grass has been shown to increase after each recurrent fire (Timothy Tunison, Hawai'i Volcanoes National Park, personal communication 1992). At Hawai'i Volcanoes and Haleakala National Parks, it has increased rapidly when released from ungulate grazing pressure, often developing local populations with nearly 100% cover. Molasses grass therefore presents a formidable problem in the management of rare plants within fenced exclosures.

3. Guinea grass (Panicum maximum). This drought-resistant, coarse, perennial grass reaches heights of over 2 meters (6.6 feet) and has strong allelopathic activity (Smith 1985). It is one of the most invasive of Lana'i's weeds of dry environments, as it forms monospecific stands and carries fire under very dry conditions.

4. Kikuyu grass (Pennisetum clandestinum). This rapidly growing, partially scrambling, rhizomatous East African grass has become a primary rangeland grass in Hawai'i. It is invading dry to wet mesic habitats as well as disturbed wet forests on all the Hawaiian Islands. More than any other species, kikuyu grass forms a thick mat that prevents the reproduction of all native plant taxa. The dryland forest at Auwahi on East Maui is an example of that (Medeiros et al. 1986). This grass may be controlled by spraying with 0.5% glyphosate (Gardner and Kageler 1983).

5. Fountaingrass (Pennisetum setaceum). This North African bunchgrass is an exceptionally aggressive weed, crowding out other species. It is a fire-stimulated grass that is infamous for carrying intense fires through formerly

barren lava flows of North Kona on the island of Hawai'i where it has become ubiquitous. The seeds are dispersed by wind. A large population of fountaingrass has recently (June 1992) been discovered at the Koele golf course on Lana'i, and attempts are underway by the landowner and the Hawai'i Department of Agriculture to eradicate it (Adams 1992).

6. Kahili ginger (Hedychium gardnerianum). This large (to 2 meters (6.6 feet) tall) ginger with bright golden-yellow flowers is an aggressive invader of wet forests of Lana'ihale. It is dispersed by birds that eat its large, fleshy, orange fruits. Once Kahili ginger establishes at a site, it spreads vegetatively, forming large, continuous clumps that displace nearly all other understory vegetation. It is especially aggressive in wet, disturbed, well-lit areas, such as open-canopied forest understory and along streambeds.

7. Tibouchina (Tibouchina herbacea). This wet forest weed from South America grows to 3 meters (9.8 feet) tall and rapidly fills openings created by disturbance, crowding out any native species present. It is considered one of the worst threats to biological diversity in reserves of the West Maui Mountains where it invaded during the 1980s. A few individuals of Tibouchina herbacea were noted on the upper slopes of Lana'ihale during a site visit on 21 October 1992 (R. Hobdy, L. Loope, A. Medeiros, and P. Thomas, personal observation 1992), apparently the first record of this species for Lana'i. It promises to become a highly invasive weed in the wet forests of Lana'i.

8. Lantana (Lantana camara). This thorny shrub has long been virtually ubiquitous in lowland dry areas of the Hawaiian Islands. It forms impenetrable thickets that crowd out other plants. Although still a major weed pest, the vigor of this species has been reduced by over a dozen biological control insects introduced to the Hawaiian Islands since 1900. Although it is a less aggressive invader than it once was, it is still locally dominant and aggressive, notably in the Abutilon eremitopetalum site in Kahea Gulch.

9. Manuka (Leptospermum scoparium). This shrub or small tree (2-5 meters (6.6 - 16.4 feet) tall) from New Zealand has been on Lana'i since the 1920s. Although it remained largely confined to a small area near Waiakeakua until the 1960s (R. Hobdy, personal communication 1992), it has since spread extensively and continues to spread, crowding out native vegetation over much of Lana'ihale.

10. Koa haole (Leucaena leucocephala). This thornless, nitrogen-fixing tree is well known for forming dense thickets that exclude native vegetation in low-elevation dryland habitats of the Hawaiian Islands (Smith 1985). An immigrant psyllid (Heteropsylla cf. incisa) that began defoliating this species in the early 1980s has greatly reduced its dominance, however. On Lana'i, many koa haole stands are represented by dead stems and only moderately vigorous regrowth. However, the health of the species on Lana'i may be increasing (Cumming 1992).

11. Firetree (Myrica faya). This rapidly growing evergreen tree, reaching up to 15 meters (49 feet) in height, invades mesic and wet habitats where it has potential to form dense, monotypic stands. Nitrogen-fixing nodules are associated with its roots, making it capable of modifying entire ecosystems. The leaves are suspected of some allelopathic activity. Myrica faya grows between 300 meters (984 feet) elevation and the summit of Lana'ihale; the southern slope of the mountain has one of the major infestations of firetree in the state (Smith 1985) and the species is rapidly colonizing habitats throughout Lana'ihale.

12. Sourbush (Pluchea symphytifolia). This plant is a shrub up to 2 meters (6.6 feet) tall that forms dense thickets in dry to wet habitats on Lana'i.

13. Strawberry guava (Psidium cattleianum). Strawberry guava is considered by some to be the single most destructive alien plant invader in Hawai'i (Smith 1985). Varying from shrub to large tree (up to 15 meters (49 feet) tall in some forests of Maui), depending on density of stocking and habitat conditions, strawberry guava

establishes dense stands and is capable of locally displacing all other plant species, aided by its allelopathic properties and dispersal of the fruit by birds.

14. Christmasberry, Brazilian pepper (Schinus terebinthifolius). Christmasberry or Brazilian pepper, a tree up to 6-8 meters (19.7 - 26.2 feet) tall, forms dense monospecific stands on Lana'i on Kanepu'u and the lower slopes of Lana'ihale. Massive dispersal by birds occurs following its fruiting in November-December. Christmasberry invades dry to mesic sites; it is rarely found in wetter sites such as upper Lana'ihale.

B. Alien mammals

Introduced mammals that have at some point affected the Lana'i cluster taxa include axis deer (Axis axis), mouflon (Ovis musimon), sheep (Ovis aries), goats (Capra hircus), cattle (Bos taurus), pigs (Sus scrofa), and rats and mice (Rattus rattus, Rattus exulans, Mus domesticus). The presence of each of these animals has contributed to the degradation and destruction of habitat and populations of the rare plant taxa on Lana'i. Of these, axis deer, mouflon, and rodents still pose serious threats. All cattle, sheep, goats, and pigs were destroyed or have been removed from the island. Pigs were eradicated on Lana'i by George Munro in the 1930s. Cattle were eliminated about 1950. Goats were eradicated by the Hawai'i State Division of Forestry and Wildlife (DOFAW) in 1981.

Individual species accounts:

1. Axis deer (Axis axis). Since 1980 on the island of Lana'i, axis deer have caused extensive habitat degradation similar to that caused by goats and cattle in the past, and now pose the greatest threat to the ecosystem and to rare taxa. Prior to the 1980s, deer had been confined to the lowlands since their introduction to the island in 1920, and numbers remained fairly low. Because of the increasing deterioration of the Lana'ihale ecosystem with chronic goat browsing and trampling, DOFAW eradicated goats in 1981. The axis deer population responded by moving into the upland habitat and increasing dramatically. It has been suggested

by Steve Montgomery that the upslope movement of deer may have been accelerated by the massive defoliation by a new immigrant psyllid leafhopper of koa haole, a major deer food source, in the lowlands (Hobdy 1993). In 1981-1982, the Lana'i deer population was estimated at 2,800 (Tomich 1986); by 1988, it had reached 10,000 (Allton 1991), with profound consequences for the Lana'ihale ecosystem. In the Cooperative Game Management Area on Lana'i (comprising most of the western part of the island), estimated axis deer populations have increased nearly 70% in the past 2 years (Cumming 1992). Axis deer browse on native vegetation, killing plants and preventing their reproduction. Their trampling removes vegetation and litter important to soil-water relations, compacts the soil, promotes erosion, and opens areas to invasion by alien plants whose seeds they disperse on their coats or in their droppings. Axis deer are currently common throughout Lana'ihale; very few patches of forest are untouched by them. They visit ridge tops most frequently, but penetrate gulches as well.

Axis deer are managed by the State of Hawai'i for recreational hunting on Lana'i, as they have been since 1959 (Tomich 1986). Axis deer were introduced to Maui in 1960; they currently occupy privately-controlled lands and are not censused with regularity by state game managers (Tomich 1986), although recently they have been reported outside of these areas.

2. Mouflon (*Ovis musimon*). Like axis deer, mouflon browse on native vegetation, destroying or damaging plants and habitat. Trampling removes vegetation and litter important to soil-water relations, compacts the soil, promotes erosion, and opens areas to invasion of alien plants whose seeds are dispersed on the animals' coats or in their droppings. Mouflon were released on Lana'i in 1954. Since 1984, they have been managed by the State of Hawai'i for recreational hunting on Lana'i. In 1981, the mouflon population of Lana'i was estimated at 900. In the Cooperative Game Management Area on Lana'i (comprising most of the western part of the island), estimated mouflon populations have increased over 70% in the past year to over 2,600 in this area alone (Cumming 1992). Mouflon are well-adapted to ridge and gully lands and are common on the drier

slopes: these are the habitats of several of the species of the Lana'i cluster.

3. Rats and mice (Rattus rattus rattus, Rattus exulans, Mus musculus). Of four rodent species introduced to the Hawaiian Islands, the arboreal black rat (Rattus rattus rattus) has probably the greatest impact on the native flora and fauna (Stone and Loope 1987). Rodents, including the arboreal black rat and, to a lesser degree, the Polynesian rat (Rattus exulans) and the house mouse (Mus domesticus), feed on the fleshy fruits and flowers of Hawaiian plants and/or girdle and strip tender branches (Cuddihy and Stone 1990). Lobelioids (such as Cyanea macrostegia ssp. gibsonii) and sandalwoods (such as Santalum freycinetianum var. lanaiense) are especially vulnerable to rodent damage.

C. Alteration of habitat by development

Currently, Lana'i is in the process of converting from an agricultural to a tourist-based economy. Hotels are being built in conjunction with an anticipated increase in the tourist industry. Although at present there are no plans for development or activities that would directly impact rare plant species, it is conceivable that negative impacts could occur. Other areas (e.g. the Abutilon menziesii site near Pukalani on Maui) are currently used for agriculture or are subject to such use. Inadequate screening of incoming agricultural items can result in disastrous consequences (e.g. potential noxious weeds).

The landowners of all areas where any of the Lana'i cluster taxa occur should be made fully aware of habitat needs of these endangered plants and should be encouraged to be actively involved in plans to protect them. Additionally, adequate screening and quarantine is necessary for incoming agricultural goods on all islands on which the Lana'i cluster taxa occur.

D. Specific threats by taxon

1. Abutilon eremitopetalum. The main threats to Abutilon eremitopetalum include:

- a. Encroaching alien plant species. Competition from encroaching exotic plant species poses by far the greatest threat. The most immediately threatening

species is Lantana camara. Leucaena leucocephala and Pluchea symphytifolia are also present.

b. Browsing and trampling by axis deer. Browsing by axis deer is another significant threat, although Abutilon eremitopetalum does not appear to be a preferred food of the deer. Deer will browse the species if other food sources become scarce (R. Hobdy, personal communication 1992). With only seven plants surviving, browsing could rapidly impact the population, and trampling could significantly affect the survival of seedlings. However, deer also have the positive effect of browsing alien invaders. The tradeoffs are not entirely clear in this case, and care must be taken, if the Abutilon eremitopetalum population is fenced from deer, that alien plants are not allowed to overwhelm the endangered species. Timely management will be required.

c. Fire. Fire is a potential threat because the area is dry much of the year. Abutilon eremitopetalum grows on lower elevation, dry ridges where fires are known to occur.

d. The very small number of extant individuals. With only seven individuals in a single population, the limited gene pool may depress reproductive vigor. Whether or not genetic limitations pose a problem, any natural or man-caused environmental disturbance could destroy the only known population.

e. The probable loss of appropriate pollinators. Since native insects may have been the pollinators of Abutilon eremitopetalum, their decline is very likely to pose an additional threat.

f. Mismanagement of the population. Since only a single population exists and the site is vulnerable to predation by herbivores, invasion by alien weeds, and drought, mismanagement of the population is a particularly critical potential threat to the existence of the species. Management tactics must be

well thought out and closely monitored to ensure that they do not jeopardize the population in unexpected ways. For example, fencing to exclude herbivores could allow unrecoverable invasion by alien plants if weeding is not initiated.

2. Abutilon menziesii. Although populations of Abutilon menziesii have been drastically reduced in the past by habitat destruction and browsing (primarily by cattle and goats), the major populations of the species on Lana'i are currently largely safe from those influences, except in cases of food shortage for axis deer (which could be caused by drought or other factors) or fire. Careful management involving research, monitoring, and manipulation when necessary can probably assure its survival. The main management problem is that disturbance from browsing by axis deer both directly threatens the species and may also aid it through controlling invasive plants (especially Panicum maximum). The main threats to Abutilon menziesii include:

a. Inappropriate environmental perturbations. Abutilon menziesii may illustrate the precarious existence of a species that does not compete well without moderate disturbance. The perpetuation of some plant species (possibly such as Abutilon menziesii) is dependent on occasional environmental perturbations to provide open areas for recolonization. The species' foothold is tenuous in situations, such as Abutilon menziesii's, where alien plants are present and can more quickly overtake such newly-created habitat and where unnatural environmental perturbations occur (instigated by man and/or exacerbated by unnatural conditions, such as the presence of a fuel source of alien grasses).

b. Encroaching alien plant species. Panicum maximum (Guinea grass) and Leucaena leucocephala (koa haole) are, at present, the primary competitors of Abutilon menziesii in its habitat on Lana'i. Although Leucaena has undergone extensive dieback due to defoliation by an immigrant psyllid that arrived in the early 1980s, it is fully capable of recovery if

the psyllid were to undergo a decline (a likely circumstance). Browsing by axis deer seems to have a quite significant effect on Leucaena at present and would have more effect if the psyllid were to decline. Leucaena is recently reported to be increasing in vigor on Lana'i (Cumming 1992). The most serious threat may be from the grass Panicum maximum, which would be much more dense and robust in the absence of deer.

c. Browsing and trampling by ungulates. Although not a preferred food of axis deer, Abutilon menziesii is significantly browsed by deer (R. Hobdy, personal communication 1992). Cattle browsing probably contributed to the decline of the species on Lana'i (where cattle were eliminated in the 1950s). One population on the island of Hawai'i was completely destroyed by cattle during an unusually dry year. Most of the plants at Pu'u o Kali on Maui are periodically subjected to cattle browsing. On Lana'i, deer browsing in current Abutilon menziesii habitat appears to have a positive aspect, since Panicum maximum and Leucaena leucocephala seem to be directly affected by browsing more than Abutilon menziesii. However, browsing and trampling of seedlings by axis deer and/or mouflon may inhibit regeneration. Further research should be done on this matter.

d. Fire. Fire has occurred occasionally in the habitat of Abutilon menziesii (R. Hobdy, personal communication 1992). Fires may be more frequent in the future now that surrounding lands are no longer in pineapple production. Populations of Abutilon menziesii have not fared too badly in past fires (R. Hobdy, personal communication 1992), but could undoubtedly be threatened by intense fires in dense Guinea grass.

e. The Chinese rose beetle. The Chinese rose beetle (Adoretus sinicus) has been documented to feed on leaves of Abutilon menziesii (Howarth 1985).

f. The probable loss of appropriate pollinators. Since native insects (especially Nesoprosope bees) may have been the pollinators of Abutilon menziesii, their decline is very likely to pose an additional threat, although the flowers now are frequently visited by introduced insects (USFWS 1986b).

g. Development. Pineapple fields adjacent to current populations probably destroyed some of this species' habitat, and a road and garbage dump have been proposed in this species' range.

3. Cyanea macrostegia ssp. gibsonii. The main threats to Cyanea macrostegia ssp. gibsonii include:

a. Browsing and habitat disturbance by axis deer. Deer have not yet fully invaded the current habitat of this taxon, though they have directly (through browsing and trampling) and indirectly (through opening up avenues for invasion of alien plants by their trampling) contributed to the taxon's decline. Browsing and habitat disturbance by axis deer promise to eliminate Cyanea macrostegia ssp. gibsonii if drastic management efforts are not undertaken.

b. Encroaching alien plant species. Kahili ginger (Hedychium gardnerianum) was observed overgrowing the only plant found at one of the Kaiholena sites in 1989 (R. Hobdy, personal communication 1992). Even small pockets of virtually undisturbed forest in the heads of gulches on the upper slopes of Lana'ihale are being invaded by Psidium cattleianum, Myrica faya, Leptospermum scoparium, Pluchea symphytifolia, Melinis minutiflora, Rubus rosifolius, Paspalum conjugatum, and other alien species. These alien species have become pervasive on adjacent ridges since the forest floor is bombarded by alien propagules, and natural openings, or openings created by habitat disturbance by axis deer, provide ample sites for these aliens to obtain a foothold. Continuing disturbance by axis deer exacerbates the alien plant invasion problem.

d. The very small number of extant individuals. With at most only 75-80 individuals in many small populations, the limited local gene pools may depress reproductive vigor.

e. The probable loss of appropriate pollinators. Since native birds may have been the pollinators of Cyanea macrostegia ssp. gibsonii, their decline is very likely to pose a major, though undocumented, threat.

4. Cyrtandra munroi. The main threats to Cyrtandra munroi include:

a. Browsing and habitat disturbance by axis deer. Deer have not yet fully invaded the current habitat of Cyrtandra munroi, though they have directly (through browsing and trampling) and indirectly (through opening up avenues for invasion of alien plants by their trampling) contributed to the taxon's decline. Browsing and habitat disturbance by axis deer promise to eliminate Cyrtandra munroi if drastic management efforts are not undertaken.

b. Encroaching alien plant species. Even small pockets of virtually undisturbed forest in the heads of gulches on the upper slopes of Lana'ihale are being invaded by Psidium cattleianum, Myrica faya, Leptospermum scoparium, Pluchea symphytifolia, Melinis minutiflora, Rubus rosifolius, Paspalum conjugatum, and other alien species. These alien species have become pervasive on adjacent ridges since the forest floor is bombarded by alien propagules, and natural openings, or openings created by habitat disturbance by axis deer, provide ample sites for these aliens to obtain a foothold. Continuing disturbance by axis deer exacerbates the alien plant invasion problem.

c. The very small number of extant individuals. With its extremely small number of populations and individuals, the limited gene pool may depress reproductive vigor.

- d. The probable loss of appropriate pollinators. The decline of native insect pollinators is very likely to pose a major, though undocumented, threat.
5. Gahnia lanaiensis. The main threats to Gahnia lanaiensis include:
- a. The small number of plants and their restricted distribution. The primary threats to Gahnia lanaiensis are the small number of plants (approximately 50-100 plants total) and its restricted distribution, which increases the potential for extinction from stochastic events.
- b. Encroaching alien plant species. Leptospermum scoparium (manuka), a weedy tree introduced from New Zealand, dominates the overstory above the large population of Gahnia lanaiensis at the Lana'ihale summit (approximately 20 plants) and will probably eventually compete with Gahnia for space. Psidium cattleianum, Myrica faya, Pluchea symphytifolia, Melinis minutiflora, Rubus rosifolius, Paspalum conjugatum, and Tibouchina herbacea are other major invaders that clearly pose threats to Gahnia lanaiensis. Disturbance by deer exacerbates the alien plant invasion problem.
- c. Browsing and habitat disturbance by axis deer. Axis deer have invaded the ridgetop habitat of this taxon and directly (through browsing and trampling) and indirectly (through opening up avenues for invasion of alien plants by their trampling) pose a threat to the continued existence of the taxon.
- d. Increased human use of the habitat. The potential for the threat of increased habitat use by humans was raised by USFWS (1991). Since perhaps as many as half the known individuals of this taxon grow adjacent to the Munro Trail (which crosses Lana'ihale), this threat must be considered serious.

6. Phyllostegia glabra var. lanaiensis. The main threats to Phyllostegia glabra var. lanaiensis include:

a. The very small number of extant individuals. It is possible that Phyllostegia glabra var. lanaiensis no longer exists. If it does exist, the limited gene pool may depress reproductive vigor. Whether or not genetic limitations pose a problem, any natural or man-caused environmental disturbance could easily destroy any or all of the few remaining populations.

b. Browsing and habitat disturbance by axis deer. Axis deer have not yet fully invaded the current habitat of this taxon, though they have directly (through browsing and trampling) and indirectly (through opening up avenues for invasion of alien plants by their trampling) contributed to the decline of this taxon. Browsing and habitat disturbance by axis deer promise to eliminate Phyllostegia glabra var. lanaiensis if drastic management efforts are not undertaken.

c. Encroaching alien plant species. Even small pockets of virtually undisturbed forest in the heads of gulches on the upper slopes of Lana'ihale are being invaded by Psidium cattleianum, Myrica faya, Leptospermum scoparium, Pluchea symphytifolia, Melinis minutiflora, Rubus rosifolius, Paspalum conjugatum, and other alien species. These alien species have become pervasive on adjacent ridges since the forest floor is bombarded by alien propagules and natural openings or openings created by habitat disturbance by axis deer provide ample sites for these aliens to take over and crowd out most native plants. Continuing disturbance by axis deer exacerbates the alien plant invasion problem.

d. The probable loss of appropriate pollinators. The decline of native insect pollinators is very likely to pose a major, though undocumented, threat.

7. Santalum freycinetianum var. lanaiense. The main threats to Santalum freycinetianum var. lanaiense include:

a. Browsing and trampling by axis deer and mouflon. The habitat of Santalum freycinetianum var. lanaiense has been severely degraded by grazing and browsing of livestock and exotic game animals. Much of the native vegetation has been removed, increasing wind erosion of the fragile soils. Trampling may directly adversely affect individual Santalum freycinetianum var. lanaiense plants because of their shallow root systems, or indirectly through destruction of the host plants they depend on. There is a high browse line on the few remaining trees.

b. Predation on fruit. Although flowering and fruiting do occur, rat predation on developing fruit has all but eliminated reproduction of Santalum freycinetianum var. lanaiense (Carr 1981, USFWS 1986a, Stemmermann in Hamilton and Conrad 1990). Cardinals have also been noted to consume large quantities of Santalum seed (Stemmermann in Hamilton and Conrad 1990), but whether this occurs with this particular variety is unknown.

c. Encroaching alien plant species. Competition from encroaching exotic plant species poses a formidable threat to the continued existence of Santalum freycinetianum var. lanaiense. The species of greatest concern are Melinis minutiflora, Andropogon virginicus, Panicum maximum, Pennisetum clandestinum (especially on East Maui), Lantana camara, Leucaena leucocephala, and Pluchea symphytifolia in dryland areas and Myrica faya, Psidium cattleianum, Leptospermum scoparium, and other species in mesic to wet sites. Disturbance by deer, mouflon and goats exacerbates the alien plant invasion problem.

d. Potential threats of taking. Extensive removal of Hawaiian sandalwoods for trade occurred from 1790 to 1820. The heart wood is valued for its fragrance

and beauty and was used in making incense and in decorative woodworking. Although sandalwood is no longer common enough for profitable commercial use, Santalum freycinetianum var. lanaiense may be threatened by individuals seeking the heart wood (USFWS 1986a).

e. Fire. Fire is a potential threat, especially in areas where alien plants have created a greater-than-normal fuel source. However, fruiting of sandalwood has been observed to be stimulated by fire in some instances (A. Medeiros and L. Loope, personal observation 1986).

f. The very small number of extant individuals. With only small, scattered populations, the limited gene pool may depress reproductive vigor.

g. "Spike disease". "Spike disease," destructive to sandalwoods in India, is suspected to affect sandalwoods on Hawai'i (Hamilton and Conrad 1990). Although not reported specifically from Santalum freycinetianum var. lanaiense, spike disease could be a threat to the taxon if it is present. Research into this disease needs to be carried out.

h. A fungus that may affect the viability of seeds. Seeds of Santalum freycinetianum have sometimes failed to germinate in cultivation, apparently due to a fungus that may have altered the viability of the seeds in fly-damaged fruits (Judd 1936). It is unknown whether this fungus affects germination of seeds in the wild. Research into this matter needs to be carried out.

8. Tetramolopium remyi. The main threats to Tetramolopium remyi include:

a. The very small number of extant individuals. Only one population of two individuals is known. The limited gene pool may depress reproductive vigor. Whether or not genetic limitations pose a problem, any

natural or man-caused environmental disturbance could easily destroy the remaining individuals.

b. Competition from invading weedy species.

Although the vegetation near the last known occurrence of Tetramolopium remyi is largely native (dominated by Heteropogon contortus and Dodonaea viscosa), alien plant species are invading the vicinity. The immediate threats are broomsedge (Andropogon virginicus) and Guinea grass (Panicum maximum), both of which are established nearby and threaten to invade Tetramolopium remyi habitat. The existing Tetramolopium remyi plants are tiny and could easily be displaced and eliminated by invading exotic species.

c. Browsing and trampling by axis deer and mouflon.

The habitat of Tetramolopium remyi has been severely degraded by grazing and browsing of livestock and exotic game animals. Much of the native vegetation has been removed, increasing wind erosion of the fragile soils. Axis deer and mouflon are both occasionally present in the vicinity of the only known population of this species. A single incident of grazing or trampling by these animals could easily destroy any or all of the few remaining individuals of this taxon.

d. Fire. Because the only population of Tetramolopium remyi grows on a dry part of the island where fires do occasionally occur, a single fire could cause extinction of the species.

e. Mismanagement of the population. Due to the extremely small number of individuals in a single population and the vulnerability of the site to predation by herbivores, invasion by alien weeds, and drought, mismanagement of the population is a particularly critical potential threat to the existence of the species. Management tactics must be well thought out and closely monitored to ensure that they do not jeopardize the population in unexpected

ways. For example, fencing to exclude herbivores without provisions to remove weeds could allow unrecoverable invasion by alien plants; excessive seed collection for propagation could lead to insufficient seeds at the site for natural reproduction; collection of meristem tissue for tissue culture could kill individuals and/or allow pathogens to become established due to tissue damage; or site disturbance by improper or careless management efforts (e.g. trampling or unmonitored fencing) could adversely affect the population's survival.

9. Viola lanaiensis. The main threats to Viola lanaiensis include:

a. Browsing and habitat disturbance by axis deer. Deer have largely invaded the habitat of this taxon, and have directly (through browsing and trampling) and indirectly (through opening up avenues for invasion of alien plants by their trampling) contributed to the taxon's decline. Browsing and habitat disturbance by axis deer promise to eliminate Viola lanaiensis if drastic management efforts are not undertaken.

b. Encroaching alien plant species. Habitat of Viola lanaiensis in gulches on the upper slopes of Lana'ihale is being invaded by Psidium cattleianum, Myrica faya, Leptospermum scoparium, Pluchea symphytifolia, Melinis minutiflora, Rubus rosifolius, Paspalum conjugatum, and other alien species. These alien species have become pervasive on adjacent ridges since the forest floor is bombarded by alien propagules, and natural openings, or openings created by habitat disturbance by axis deer, provide ample sites for these aliens to obtain a foothold. Continuing disturbance by axis deer exacerbates the alien plant invasion problem.

c. The very small number of extant individuals. With fewer than 80 scattered individuals in small populations, limited local gene pools may depress reproductive vigor in Viola lanaiensis.

d. The probable loss of appropriate pollinators. Since native birds may have been the pollinators of Viola lanaiensis, their decline is very likely to pose a major, though undocumented, threat.

e. Slugs. Slug damage and live slugs have been observed on Viola lanaiensis (R. Hobdy, L. Loope, A. Medeiros, and P. Thomas, personal observation 1992). The severity of this threat is unknown.

7. CONSERVATION EFFORTS

General

In the first part of the twentieth century, the family of Charles Gay became alarmed at the condition of the island's forested watersheds and began efforts to eradicate goats and sheep and began to fence the summit forest. In 1910, forester R.S. Hosmer was invited to help plan for the long-term recovery of the island. Hosmer wrote a report in 1910 recommending, among other measures, additional fencing and animal eradication (Hobdy 1993). As early as 1911, it was recognized that goats, sheep, and pigs were threats to the vegetation of Lana'i. Efforts to control goats and sheep were undertaken at this time, with significant effect. George C. Munro, who became the manager of the Lana'i company in 1911, stated: "When the wild sheep and goats had been cleared... the undergrowth over the whole forest made a wonderful recovery." In 1927, Charles S. Judd noted "the improvement in the growth of the native forest" in the 8 years since his previous visit to the island of Lana'i. Cattle posed an even bigger threat to the native forest of Lana'i until the decision was made in 1950 to remove them from the island. Goats were eradicated from the island in 1981 by the State of Hawai'i Department of Land and Natural Resources. A more detailed account of the history of early conservation measures can be found in Robert Hobdy's (1993) article Lana'i - A Case Study: The Loss of Biodiversity on a Small Hawaiian Island.

The Federal listing of each of the taxa in the Lana'i cluster as endangered has afforded each the protection of the ESA. Hawai'i state law automatically protects any species Federally listed as endangered (Hawaii Revised Statutes Chapter [HRS] 195D). Additional legal protection is automatically granted by the ESA to

any species protected by State law. Until the Lana'i cluster taxa were protected by the ESA, there were no State laws or regulatory mechanisms to protect or prevent further decline of these plants on private land. Hawai'i State law prohibits taking of endangered flora and encourages conservation by State government agencies. ("Take" as defined by Hawai'i State law means "to harass, harm..., wound, kill..., or collect endangered... species... or to cut, collect, uproot, destroy, injure, or possess endangered... species of... land plants, or to attempt to engage in any such conduct" [HRS 195D].) All of the Lana'i cluster taxa are high-priority taxa for protection under Hawai'i State law since their "extinction within the State would... terminate... their existence in the world" (HRS 195D-5(d)). Because of their protection by State laws of Hawai'i, 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, or 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].

Critical habitat was not designated for any of the taxa in the Lana'i cluster. Such designation was not deemed prudent because of the possible 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 (USFWS 1986a, 1986b, 1991; USFWS et al. 1992).

The 1992 Hawai'i Task Force Meeting on Endangered Hawaiian Plants was arranged by NTBG and the Center for Plant Conservation. This meeting was attended by 50 participants from 26 organizations. The status of each of the Lana'i cluster taxa was reviewed along with those of approximately 300 other rare Hawaiian plant taxa. Other relevant issues addressed at the meeting included methods of seed storage, plant reintroduction protocols, criteria for ranking rare plants, and prioritization of conservation efforts for rare plants (Loyal Mehrhoff [Bernice P. Bishop Museum, Honolulu, Hawai'i], personal communication 1992).

Seeds and/or plants of some of these taxa have been collected by NTBG & HPCC, located on the island of Kaua'i, Hawai'i. Table 2 presents NTBG's holdings as of August 1992. NTBG's plans for these holdings include research into propagation

methods and feasibility of long-term seed storage (D. Ragone, personal communication 1993).

Table 2. Seeds and plants of the Lana'i cluster endangered plant taxa at the National Tropical Botanical Garden, Kaua'i (Teri Teasdale and Diane Ragone, NTBG, personal communications 1993).

Taxon	Seeds	Plants
<u>Abutilon eremitopetalum</u>	2990	14
<u>Abutilon menziesii</u>	4377	72
<u>Cyanea macrostegia</u> ssp. <u>gibsonii</u>	570	0
<u>Cyrtandra munroi</u>	0	0
<u>Gahnia lanaiensis</u>	1300	0
<u>Phyllostegia glabra</u> var. <u>lanaiensis</u>	0	0
<u>Santalum freycinetianum</u> var. <u>lanaiense</u>	0	0
<u>Tetramolopium remyi</u>	295	0
<u>Viola lanaiensis</u>	55	0

Individual taxa

Conservation measures and past research are presented here for each taxon for which specific information is available. Additional sources of information regarding research on each taxon can be found in Mill et al. (1988).

A. Abutilon eremitopetalum. Abutilon eremitopetalum is currently cultivated at the Hawai'i State Department of Land and Natural Resources' baseyard on Maui and at NTBG. Before Abutilon eremitopetalum's listing as Federally endangered, progeny of those plants had been distributed to other individuals for cultivation (R. Hobdy, personal communication 1992). The HPCC collected seed from Abutilon eremitopetalum as recently as May 1990 (HPCC #905216).

Abutilon eremitopetalum is represented in the NTBG, the Waimea Arboretum and Botanical Garden, and the Amy Greenwell Ethnobotanical Garden. HPCC has in storage approximately 3000 seeds of Abutilon eremitopetalum as of August 1992 and has 14 plants in cultivation (T. Teasdale, personal communication 1992). These plants are hybridizing with the A. menziesii growing next to

them, so care should be taken to minimize this problem in other ex situ conservation efforts.

B. Abutilon menziesii. Currently, management efforts are being carried out to protect the only known population of Abutilon menziesii on the island of Hawai'i. This population is on privately-owned land that is being developed for residential purposes; the landowning corporation, Nansay Hawaii, is cooperating with DOFAW to implement plans for protecting this population (E. Funk, personal communication 1992).

Abutilon menziesii is represented in the NTBG, the Waimea Arboretum and Botanical Garden, the Honolulu Botanic Garden, and the Amy Greenwell Ethnobotanical Garden. As of August 1992 the HPCC had in storage a total of over 4000 seeds from Abutilon menziesii from the islands of Lana'i, Hawai'i, and Maui (from several plants) and has 72 plants in cultivation (T. Teasdale, personal communication 1992). Research on this taxon includes isozyme analysis and some research into pollination biology (HHP database citation reference U90BRU01; R. Hobdy, personal communication 1992).

In cultivation, Abutilon menziesii seeds germinate readily in a cinder medium in as little as 1 week, and grow quickly after transplanting to individual containers. Cultivated plants are reported to be thriving on windward Maui at elevations from 38-56 meters (125-185 feet) with approximately 1270-1900 millimeters (50-75 inches) of rainfall annually (A. Palomino, personal communication 1992).

C. Cyanea macrostegia ssp. gibsonii. As of August 1992 the HPCC had in storage a total of 570 seeds of Cyanea macrostegia ssp. gibsonii from Lana'i (T. Teasdale, personal communication 1992).

D. Cyrtandra munroi. No conservation efforts specifically targeted at Cyrtandra munroi are known. However, some research has been done into the pollination biology of other Cyrtandra (e.g. Roelofs 1979).

E. Gahnia lanaiensis. As of August 1992 the HPCC had in storage a total of 1300 seeds from Gahnia lanaiensis from Lana'i (T. Teasdale, personal communication 1992).

F. Phyllostegia glabra var. lanaiensis. No conservation efforts specifically targeted at Phyllostegia glabra var. lanaiensis are known.

G. Santalum freycinetianum var. lanaiense. Santalum freycinetianum var. lanaiense is present in the Kanepu'u preserve on Lana'i (R. Alan Holt, TNCH, personal communication 1992; R. Hobdy, personal communication 1992). This preserve was made possible by a permanent conservation easement with the landowners granted to TNCH, with funding assistance by the State of Hawai'i Natural Area Partnership Program. The Kanepu'u preserve will be managed by TNCH for native forest conservation and preservation (Monson 1992).

A symposium on sandalwood in the Pacific was held in April 1990 in Honolulu. A state-of-knowledge synthesis and collection of papers was produced including information regarding conservation efforts in various countries that could be applicable to Santalum freycinetianum var. lanaiense. Information regarding certain aspects of research (e.g. seed collection, germination, and longevity; other propagation methods; host requirements) on various taxa in the genus was thought to be generally applicable to other taxa as well (Hamilton and Conrad 1990).

H. Tetramolopium remyi. The HPCC collected fruit from Tetramolopium remyi from Lana'i in May 1990 (HPCC #905214). Two hundred ninety-five (295) seeds were stored in the HPCC collection as of June 1993 (D. Ragone, personal communication 1993). Also, the species has been grown by the Hawai'i Department of Land and Natural Resources on Maui but no material is currently in cultivation there (R. Hobdy, personal communication 1992). Research has been conducted on various aspects of Tetramolopium remyi including its evolutionary relationships (Lowrey and Crawford 1985). The most recent revision of the genus was prepared by Lowrey (1986).

I. Viola lanaiensis. As of August 1992 the HPCC had in storage a total of 55 seeds from Viola lanaiensis from Lana'i (T. Teasdale, personal communication 1992).

8. RECOVERY STRATEGY

A. General Strategy

The plan for recovery that is detailed in the following Step-down narrative begins with the protection of current habitat through purchases, easements and/or agreements with landowners. Current threats to the species are addressed through fencing to exclude ungulates, removal/control of alien plants, protection from fire, control of rodents, insects and disease, protection from human disturbance, collection, storage and maintenance of genetic material and a comprehensive monitoring program. A research program is also recommended to distinguish between similar taxa, determine if Gahnia lanaiensis is native to Hawaii, study the growth and reproductive viability of each taxon, determine the parameters of viable populations of each taxon, study possible pests and diseases and to use the results of research to improve management practices.

A program of augmentation of very small populations and re-establishment of new populations within the historical range of the species is also needed. That includes selection of areas for augmentation and re-establishment, determination of the best methods for ex situ propagation and transplanting, selection of the best genetic stock for each area, propagation of suitable stock, preparation of sites for seeding and/or transplanting and monitoring and maintenance of new individuals and populations as they are established.

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

B. Prioritization

All tasks in the stepdown narrative should be carried out for each taxon as applicable. Prioritization of tasks should be considered on a per-taxon basis as some tasks may be more important to certain taxa than to others. Note that revision of criteria for downlisting based on scientific data is an important task for each taxon.

The Lana'i cluster taxa are ranked with a priority from 1 to 9, 1 being the highest priority (see Table 3). The criteria used in ranking priorities are subjective and should be used as general guides only. Rationale for priorities is based on (1) the projected feasibility of implementing successful recovery plans for each taxon, (2) the number of extant populations and individuals of each taxon, (3) the immediacy of threats to each taxon, and (4) the cost-effectiveness of proposed plans for each taxon.

These priorities are not meant to replace the USFWS recovery priority numbers that are developed for all endangered species, and are not meant to suggest that all tasks should be completed for the #1 priority species before important tasks for other species are begun.

Table 3. Priorities for the Lana'i cluster taxa.

<u>Priority</u>	<u>Taxon</u>
1	<i>Abutilon eremitopetalum</i>
2	<i>Abutilon menziesii</i>
3	<i>Santalum freycinetianum</i> var. <i>lanaiense</i>
4	<i>Tetramolopium remyi</i>
5	<i>Cyanea macrostegia</i> ssp. <i>gibsonii</i>
6	<i>Cyrtandra munroi</i>
7	<i>Gahnia lanaiensis</i>
8	<i>Phyllostegia glabra</i> var. <i>lanaiensis</i>
9	<i>Viola lanaiensis</i>

Abutilon eremitopetalum was assigned the highest priority because of the existence of only a single population and the relatively small scale of the initial tasks involved for its recovery. *Abutilon menziesii* ranks second because of the better chance it has of recovery due to its larger population size and its resistance to some of its current threats and, provided with appropriate management, its relatively good chance of recovery. *Santalum freycinetianum* var. *lanaiense* has a scattered distribution of small populations. Due to recent research into propagation of others in its genus, the prospects for recovery of this species are enhanced (given appropriate management actions), despite the degraded state of most of the habitats that it

occupies and its current inability to naturally reproduce because of seed predation and lack of suitable habitat for seedlings. Although critically low in numbers--and therefore in perhaps the greatest need of immediate action to save genetic material--Tetramolopium remyi ranks last among the non-Lana'ihale taxa. Because of stochastic factors related to its possibly annual habit and the severe degradation of its present habitat, management for long-term recovery for this taxon may prove to be difficult.

The taxa that are restricted mainly or solely to the Lana'ihale area of Lana'i (Cyanea macrostegia ssp. gibsonii, Cyrtandra munroi, Gahnia lanaiensis, Phyllostegia glabra var. lanaiensis, and Viola lanaiensis) have been placed together--and last--in functionally arbitrary order (alphabetically); the success of recovery efforts for these taxa is dependent upon the large-scale task of preservation of the natural Lana'ihale ecosystem.

PART II. RECOVERY

Objectives

Objectives for stabilizing, downlisting, and delisting are provided for the Lanai plant cluster taxa. The order of tasks listed in the step-down outline and narrative does not necessarily designate the order in which these tasks should be implemented. Priorities for action and recommended time-frames are contained in the Implementation Schedule of this plan.

An endangered species is defined in section 3 of the Endangered Species Act as any species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

For the purposes of this section, a population is defined as a discrete unit with sufficient distance between neighboring populations that the two are not affected by the same small-scale events (such as a landslide), and are not believed to be cross-pollinated. Mature individuals are defined as those either known or believed to be capable of reproduction. In general, long-lived perennials are those taxa either known or believed to have life spans greater than 10 years; short-lived perennials are those known or believed to have life spans greater than 1 year but less than 10 years.

The long-lived perennials in this plan are: Abutilon eremitopetalum, Abutilon menziesii, Cyanea macrostegia ssp. gibsonii, and Santalum freycinetianum var. lanaiense.

The short-lived perennials in this plan are: Cyrtandra munroi, Gahnia lanaiensis, Phyllostegia glabra var. lanaiensis, Tetramolopium remyi and Viola lanaiensis.

Because we have only limited knowledge of the life history of each of these taxa with respect to specific requirements for their short-term and long-term survival, only tentative criteria for stabilizing, downlisting, and delisting are established here. These criteria were formulated based on recommendations by the Hawaii and Pacific Plants Recovery Coordinating Committee, as well as the International Union for Conservation of Nature and Natural Resources' (IUCN's) draft red list categories (Version 2.2) and the advice and recommendations of various biologists and knowledgeable individuals.

Additional information is needed about each of the Lanai cluster taxa so that more meaningful recovery objectives can be quantified.

Interim Objectives

The interim objective is to stabilize all existing populations of the Lanai taxa. To be considered stable, each taxon must be managed to control threats (e.g., fenced) and be represented in an ex situ collection. In addition, a minimum total of three populations of each taxon should be documented on Lanai and, if possible, at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing and increasing in number, with a minimum of 25 mature individuals per population for long-lived perennials and a minimum of 50 mature individuals per population for short-lived perennials.

Downlisting Objectives

For downlisting, a total of five to seven populations of each taxon should be documented on Lanai and at least one other island where they now occur or occurred historically. In certain cases, however, a particular taxon may be eligible for downlisting even if all five to seven of the populations are on only one island, provided all of the other recovery criteria have been met and the populations in question are widely distributed and secure enough that one might reasonably conclude that the taxon is not in danger of extinction throughout all or a significant part of its range.

Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials, and a minimum of 300 mature individuals per population for short-lived perennials. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered.

Delisting Objectives

For delisting, a total of 8 to 10 populations of each taxon should be documented on Lanai and at least 1 other island where

they now occur or occurred historically. As with downlisting, there may be cases in which a particular taxon may be eligible for delisting even if all 8 to 10 of the populations are on only 1 island, provided all of the other recovery criteria have been met and the populations in question are widely distributed and secure enough that one might reasonably conclude that the taxon is not likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials and a minimum of 300 mature individuals per population for short-lived perennials. Each population should persist at this level for a minimum of 5 consecutive years.

These recovery objectives may be refined and this recovery plan revised as more is learned about the life history of the taxa and population modeling is conducted.

2. STEPDOWN OUTLINE

1. Secure and manage current populations and their habitat.
 11. Secure habitat for current populations.
 111. Identify all extant wild populations.
 112. Identify areas for preservation.
 113. Secure landowner cooperation and/or obtain conservation agreements.
 1131. Protect habitat owned by Castle & Cooke Land Co.
 1132. Protect habitat owned by Hawaiian Commercial & Sugar Co.
 1133. Protect habitat owned by Haleakala Ranch Co.
 1134. Protect habitat owned by Nansay Hawai'i.
 1135. Protect habitat owned by Ulupalakua Ranch.
 1136. Protect habitat owned by State of Hawai'i.
 1137. Protect habitat owned by Hawaiian Homelands.
 114. Work with State of Hawaii to more actively Enforce legal protection from development.
 12. Manage current populations.
 121. Exclude ungulates through fencing.
 1211. Determine fencing strategy for Lana'ihale areas.
 1212. Implement fencing and maintenance strategy for Lana'ihale areas.
 1213. Determine fencing strategy for lowland areas of Lana'i.
 12131. Develop fencing strategy for Lana'i Abutilon menziesii populations.
 12132. Implement fencing for Lana'i Abutilon menziesii populations.
 12133. Fence Tetramolopium remyi population.
 12134. Fence Abutilon eremitopetalum population.

- 1214. Determine fencing strategies for Maui.
 - 12141. Develop fencing strategy for Maui Abutilon menziesii populations.
 - 12142. Implement fencing of Maui Abutilon menziesii populations.
 - 12143. Fence Maui Cyrtandra munroi population.
 - 12144. Determine need to fence Santalum sites on Maui.
 - 12145. Fence Santalum individuals on Maui, if needed.
- 1215. Determine fencing strategies for Hawai'i.
 - 12151. Determine need for fencing on Hawai'i.
 - 12152. Fence Abutilon menziesii individuals on Hawai'i, if needed.
- 1216. Remove ungulates within fenced areas.
- 1217. Monitor fenced areas for ungulates.
- 1218. Determine effects of excluding ungulates.
- 122. Develop and/or support feral herbivore removal programs.
- 123. Conduct essential alien plant control.
 - 1231. Determine effective control methods.
 - 1232. Implement weed control.
 - 12321. Implement weed control for Lana'ihale sites.
 - 12322. Implement weed control for the Lana'i Abutilon menziesii populations.
 - 12323. Implement weed control for the Tetramolopium remyi population.
 - 12324. Implement weed control for the Abutilon eremitopetalum population.
 - 12325. Implement weed control efforts for Kanepu'u Santalum site.

- 12326. Implement weed control for the Maui Abutilon menziesii populations.
- 12327. Implement weed control for the Maui Cyrtandra munroi population.
- 12328. Implement weed control for the E. Maui Santalum site.
- 12329. Implement weed control for the W. Maui Santalum site.
- 123210. Implement weed control for the Abutilon menziesii individuals on Hawai'i, if needed.
- 1233. Prevent introduction of new alien species to Hawai'i.
- 124. Provide necessary fire protection.
 - 1241. Develop fire protection plans.
 - 1242. Implement fire protection plans.
- 125. Control predation and disease.
 - 1251. Control rodents.
 - 12511. Control rodents at Kanepu'u.
 - 12512. Control rodents at Lana'ihale site.
 - 12513. Control rodents at E. Maui Santalum site.
 - 12514. Control rodents at W. Maui Santalum site.
 - 12515. Control rodents in other areas, if needed.
 - 1252. Control Chinese rose beetle (Adoretus sinicus) as needed.
 - 1253. Control hibiscus scale as needed.
 - 1254. Control spike disease as needed.
 - 1255. Control Santalum heart rot as needed.
 - 1256. Control Santalum seed fungus as needed.
- 126. Ensure availability of pollination vectors.
 - 1261. Ensure that natural pollination vectors remain available.

- 1262. Compensate for missing pollination vectors.
 - 127. Protect areas from potential direct threats from humans.
 - 128. Monitor status of wild populations.
 - 129. Maintain genetic stock ex situ.
2. Conduct essential research.
- 21. Determine native versus alien status of questionable taxa.
 - 22. Collect diagnostic data on crucial associated ecosystem components.
 - 23. Map alien vegetation.
 - 24. Study various aspects of growth.
 - 25. Study reproductive viability.
 - 26. Determine parameters of viable populations.
 - 27. Determine the degree of threats posed by and nature of interactions with selected diseases/introduced species.
 - 271. Determine the degree of threat posed by the Chinese rose beetle (Adoretus sinicus) to Abutilon eremitopetalum and A. menziesii.
 - 272. Determine the degree of threat posed by hibiscus scale to Abutilon eremitopetalum and A. menziesii.
 - 273. Determine the degree of threat posed by spike disease to Santalum freycinetianum var. lanaiense.
 - 274. Determine the degree of threat posed by Santalum heart rot to Santalum freycinetianum var. lanaiense.
 - 275. Determine the degree of threat posed by the reported seed viability-altering fungus to Santalum freycinetianum var. lanaiense.
 - 276. Determine mechanisms of impact of other diseases or pests.
 - 28. Determine effective control methods to combat selected diseases/introduced species.
 - 281. Determine effective control methods for rodents.
 - 282. Determine effective control methods for the Chinese rose beetle (Adoretus sinicus) on Abutilon eremitopetalum and Abutilon menziesii.

283. Determine effective control methods for hibiscus scale on Abutilon eremitopetalum and Abutilon menziesii.
 284. Determine effective control methods for spike disease on Santalum freycinetianum var. lanaiense.
 285. Determine effective control methods for Santalum seed fungus on Santalum freycinetianum var. lanaiense.
 286. Determine effective control methods for Santalum heart rot on Santalum freycinetianum var. lanaiense.
 287. Other diseases and introduced pests.
 288. Evaluate results and use in future management.
3. Expand existing wild populations.
 31. Develop plans for expansion of each population.
 311. Identify sites for expansion.
 312. Identify material to be used for expansion.
 313. Determine optimum propagation methods.
 3131. Determine optimum propagation methods for Abutilon eremitopetalum.
 3132. Determine optimum propagation methods for Abutilon menziesii.
 3133. Determine optimum propagation methods for Cyanea macrostegia ssp. gibsonii.
 3134. Determine optimum propagation methods for Cyrtandra munroi.
 3135. Determine optimum propagation methods for Gahnia lanaiensis.
 3136. Determine optimum propagation methods for Phyllostegia glabra var. lanaiensis.
 3137. Determine optimum propagation methods for Santalum freycinetianum var. lanaiense.
 3138. Determine optimum propagation methods for Tetramolopium remyi.
 3139. Determine optimum propagation methods for Viola lanaiensis.
 314. Determine appropriate reintroduction techniques.
 32. Implement expansion plans.
 321. Propagate ex situ.

- 322. Prepare sites.
 - 323. Plant.
 - 324. Monitor and maintain new individuals.
4. Reestablish wild populations within the historic range.
- 41. Investigate feasibility and desirability of reintroduction.
 - 42. Develop specific plans for re-establishment.
 - 421. Identify sites for re-establishment.
 - 422. Identify material to be used for re-establishment.
 - 4221. Identify material for Abutilon eremitopetalum re-establishment on Lana'i.
 - 4222. Identify material for Abutilon menziesii re-establishment on Hawai'i and Oahu.
 - 4223. Identify material for Cyrtandra munroi re-establishment on Maui.
 - 4224. Identify material for Gahnia lanaiensis re-establishment on Lana'i.
 - 4225. Identify material for Phyllostegia glabra var. lanaiensis re-establishment on Lana'i.
 - 4226. Identify material for Tetramolopium remyi re-establishment on Lana'i and Maui.
 - 4227. Identify material for Viola lanaiensis re-establishment on Lana'i.
 - 43. Implement re-establishment plans.
 - 431. Secure re-establishment sites.
 - 432. Prepare re-establishment sites.
 - 433. Plant.
 - 434. Monitor and maintain new populations.
5. Validate recovery objectives.
- 51. Determine number of populations needed for long term survival.
 - 52. Refine/revise downlisting and delisting criteria.

3. STEPDOWN NARRATIVE

For any activities that require site visits, precautions should always be taken to prevent introduction of organisms (particularly plants, via seeds) to the visited areas and to minimize the impact of the site visit.

1. Secure and manage current populations and their habitat.

Measures must be taken to protect wild populations of the Lana'i cluster plants. Threats to wild populations of the Lana'i cluster taxa should be eliminated. It is critical that adequate and acceptable habitat be available for the Lana'i cluster taxa; under the present circumstances, that will require active protection and management. Protection of wild populations of each of the Lana'i cluster taxa through basic habitat management is the crux of this task.

For the purposes of this plan, the current occurrences of the 9 taxa have been grouped into 40 separate management sites, which are listed in Table 4. These divisions are based on limited information and should be changed if further information on area, topography, threats, etc. suggests that different groupings would be more effective.

11. Secure habitat for current populations.

Protection of current populations and habitats through cooperative agreements, law enforcement and other means is essential.

111. Identify all extant wild populations.

Surveys of all reported and possible occurrences of each taxon should be conducted. Occurrence data, including presence in or absence from previously-reported sites (as well as site notes) and all relevant information for newly-reported occurrences, should be carefully documented. Detailed site information (including directions, maps, global positioning system (GPS) data, and narratives) is recommended for each site.

112. Identify areas for preservation.

Table 4 lists 40 sites suggested for preservation. These sites should include areas adequate for buffer zones and fire breaks and for expansion when necessary. Similar areas around each newly-discovered population of each taxon should be identified and targeted for protection and management.

113. Secure landowner cooperation and/or obtain conservation agreements.

In order to ensure maximum protection for the Lana'i cluster plants while they are on privately-owned lands (as are most known populations), it is essential to secure landowner cooperation with planned conservation efforts. Long-term cooperative management plans should be arranged (similar to the Kanepu'u preserve on Lana'i) for as much habitat as possible for each

Table 4. Possible Management Sites for the Lana'i Cluster Taxa

Site #	Location (maps in Appendix B)	Populations present (# of individuals)
LANA'I - lowlands		
1	N. side of Aualua Ridge 220 m (720 ft)	<u>T. remyi</u> (2)
2	Kanepuu 518 m (1700 ft)	<u>Santalum</u> (<20)
3	N. Fork of Kahea gulch 240-320 m (787-1050 ft)	<u>A. eremitopetalum</u> (7)
4	Pu'u Mahanalua (Twin Peaks) 370 m (1210 ft) - E. site	<u>A. menziesii</u> (most* of 200)
5	Pu'u Mahanalua - Middle site	<u>A. menziesii</u> (3 clumps*)
6	Pu'u Mahanalua - W. site	<u>A. menziesii</u> (1 clump*)
7	N. of Kaunalapau Rd. - S. site	<u>A. menziesii</u> (most* of 400)
8	N. of Kaunalapau - Middle site	<u>A. menziesii</u> (2 clumps*)
9	N. of Kaunalapau - N. site	<u>A. menziesii</u> (2 clumps*)
LANA'I - Lana'ihale		
10	Kunua gulch # 1	<u>Cyanea</u> (1) & <u>Viola</u> (27)
11	Kunua gulch # 2	<u>Cyanea</u> (5)
12	Waiialala gulch	<u>Cyanea</u> (6)
13	gulch between Kunua & Waiialala #1	<u>Cyanea</u> (10)
14	Lana'ihale summit #1	<u>Cyanea</u> (7) & <u>Gahnia</u> (20)
15	Lana'ihale summit #2	<u>Cyanea</u> (42)
16	Lana'ihale summit #3	<u>Cyanea</u> (3) & <u>Santalum</u> 2 pop's, (1 & 5)
17	gulch between Kunua & Waiialala #2	<u>Cyrtandra</u> (1)
18	gulch between Kunua & Waiialala #3	<u>Santalum</u> (3)
19	gulch between Kunua & Waiialala #4	<u>Viola</u> (13)

20	Kapolaku drainage 840-855 m (2750 - 2800 ft)	<u>Cyrtandra</u> 2 pop's (1 & 6)
21	Kapolaku drainage # 2	<u>Cyrtandra</u> 3 pop's (5 & 1 & 3) & <u>Santalum</u> 2 pop's (5 & 2)
22	E. Hauola trail 945 m (3100 ft)	<u>Gahnia</u> (2)
23	E. of road at Haalelepaakai 1015 m (3330 ft)	<u>Gahnia</u> (3) & <u>Santalum</u> (1)
24	Haalelepaakai trail 990-1020 m (3250-3350 ft)	<u>Gahnia</u> (22)
25	Puulelelu Ridge - N. Side 980 m (3200 ft)	<u>Santalum</u> (2) & <u>Viola</u> 2 pop's (18 & 20)
26	S. of Waiakeakua 953 m (3100 ft)	<u>Santalum</u> (3)
27	Pu'u Alii 840-858 m (2750-2800 ft)	<u>Santalum</u> (11)
28	Kaonohiokala Ridge 800 m (2625 ft)	<u>Santalum</u> (1)
29	Kaonohiokala Ridge 868 m (2850 ft)	<u>Santalum</u> (2)
30	Hauola E. Trail 902 m (2960 ft)	<u>Santalum</u> (1)
31	Kahinahina Ridge 867-903 m (2840-2960 ft)	<u>Santalum</u> (18)
MAUI		
32	Kalialinui gulch - N. site	<u>A. menziesii</u> (8)
33	Kalialinui gulch - middle site	<u>A. menziesii</u> (16)
34	Kalialinui gulch - S. site	<u>A. menziesii</u> (2)
35	E. of Pu'uokali	<u>A. menziesii</u> (1)
36	W. of Pu'uokali	<u>A. menziesii</u> (5)
37	Makamakaole area	<u>Cyrtandra</u> (30+)
38	Leeward E. Maui 1065-1980 m (3500-6500 ft)	<u>Santalum</u> (about 20)
39	Leeward W. Maui 910-1370 m (3000-4500 ft)	<u>Santalum</u> (few hundred)
HAWAII		
40	Puako'	<u>A. menziesii</u> (1 pop.)

* These terms are used because exact counts have not been conducted.

taxon. Management agreements, cooperative agreements, conservation easements and/or lease or fee purchases for the benefit of the Lana'i cluster taxa should be pursued.

1131. Protect habitat owned by Castle & Cooke Land Co.

Protection should be arranged for the Lana'i sites listed in Table 4, all of which are owned by Castle & Cooke Land Co. Site 2 has already been protected through a conservation easement with The Nature Conservancy of Hawai'i.

1132. Protect habitat owned by Hawaiian Commercial & Sugar Co.

Protection should be arranged for sites 32, 33 & 34, which are owned by Hawaiian Commercial & Sugar Co.

1133. Protect habitat owned by Haleakala Ranch Co.

Protection should be arranged for the parts of sites 35 & 36, which are owned by Haleakala Ranch Co.

1134. Protect habitat owned by Nansay Hawai'i.

Protection should be arranged for site 40, which is owned by Nansay Hawai'i.

1135. Protect habitat owned by Ulupalakua Ranch.

Protection should be arranged for the part of site 38, which is owned by Ulupalakua Ranch.

1136. Protect habitat owned by State of Hawai'i.

Protection should be arranged for sites 37, 39 and the part of site 38 owned by the State of Hawai'i.

1137. Protect habitat owned by Hawaiian Homelands.

Protection should be arranged for the parts of sites 35 and 36, which are owned by Hawaiian Homelands.

114. Work with State of Hawaii to more actively enforce legal protection from development.

Hawai'i State laws (Chapter 195D of the Hawaii Revised Statutes), automatically invoked by the listing of the Lana'i cluster taxa as Federally endangered, provide protection against taking of endangered plants on private lands. Protection provided by State law is reinforced by the ESA. State and Federal agencies will work together to improve enforcement of these

laws to ensure that the Lana'i cluster taxa are not unduly disturbed.

12. Manage current populations.

Management of habitat for the benefit of the Lana'i cluster taxa must occur, including control of threats to their existence. Some of the following management actions are relevant to certain taxa only.

121. Exclude unguulates through fencing.

To allow adequate site management, occurrences of the Lana'i cluster taxa must be physically isolated from unguulates by fencing, as appropriate. Possible exceptions to initial fencing are some Abutilon menziesii sites. Although this approach is costly, it does work, as demonstrated at Hawai'i Volcanoes and Haleakala National Parks and elsewhere, and is a feasible solution for feral mammal control in Hawai'i (Stone 1992). Eradication of deer island-wide does not appear to be a feasible option at this time because of very strong public support of hunting on Lana'i. If deer are allowed to continue to degrade the upper slopes of Lana'ihale, alien species such as strawberry guava, manuka, and firetree will become so ubiquitous that postage stamp-sized reserves will be indefensible.

1211. Determine fencing strategy for Lana'ihale areas.

Three options for fencing the Lana'ihale taxa (sites 10-31 in Table 4) are presented along with an analysis of advantages and problems with each approach. Based on site evaluations (including feasibility of implementation and maintenance), projected relative effectiveness of each method, and available finances, determination needs to be made as to which method(s) to implement.

A combination of methods will probably be the most effective strategy, in that if adequate monitoring of smaller plots is available, unguulates could be excluded more quickly from the areas immediately surrounding populations of the Lana'i cluster taxa while larger-scale, longer-term projects are being undertaken.

One method would include the fencing of the entire uplands area of Lana'ihale, including the lowlands to the coast (Figure 18). This proposed fence location has numerous benefits, including the following points: (1) This plan allows for exclusion of axis deer from a 100 square kilometer (40 square mile) area (about 30% of the 360 square kilometer (140 square mile) island), including most endangered species habitat, while most of the remainder of the island (including all of the State of Hawai'i's Cooperative Game Management Area) is kept as

deer habitat, providing for needs of local hunters. (2) Fencing can be constructed over moderate terrain adjacent to existing roads. Only about 16-22 kilometers (10-14 miles) of fence would be required for this approach, keeping construction and maintenance costs to a moderate level. (3) The problem of washouts of fence during heavy rains (which would be an expensive, difficult, and chronic problem with fences at higher elevations) is virtually eliminated. (4) Habitat damage from fence construction across steep, wet slopes is avoided. Additionally, (5) other rare taxa would benefit from management actions proposed in this plan (e.g. Ctenitis squamigera, Cyanea grimesiana ssp. grimesiana, Exocarpos gaudichaudii, Hedyotis mannil, Hedyotis schlechtendahlana var. remyi, Melicope munroi, Wikstroemia bicornuta, as well as the single remaining native forest bird species and numerous rare native invertebrates), and (6) protection of the crucial Lana'ihale watershed is made possible, allowing for long-term recharge of the aquifer and assurance that Lana'i's domestic water needs can be met. The main disadvantage of this fencing scheme is the increase in fuel (grasses) buildup for fires that may occur after herbivore exclusion in the leeward lowlands (buildup of fuel for fires after ungulate exclusion in wet areas such as Lana'ihale does not usually occur). A program to replace alien plants with native dryland species may help to alleviate this threat. Some means to prevent axis deer from swimming into the protected area would have to be devised if this first option is to be effective.

A second option is to fence Lana'ihale above approximately 600 meters (2000 ft) elevation. However, if occurrences of specific taxa fall outside of this fencing area, fencing and herbivore removal should also be provided around areas where these plants grow. In this scenario, all of the best remaining habitat for the Lana'ihale taxa would be fenced. A very rough estimate (based on a topographical map) of the amount of fencing required for this approach would be about 30-50 kilometers (20-30 miles), which would enclose approximately 35 square kilometers (14 square miles). However, due to the topography of the areas to be fenced, proper construction may be impossible and the initial building costs would be extremely high (R. Hobdy, personal communication 1992; A. Holt, personal communication 1992). Due to the topography of the area and frequent high waters in the many gulches that would have to be fenced, adequate maintenance of such a fence may be impossible and would certainly be extremely expensive.

LANA'I

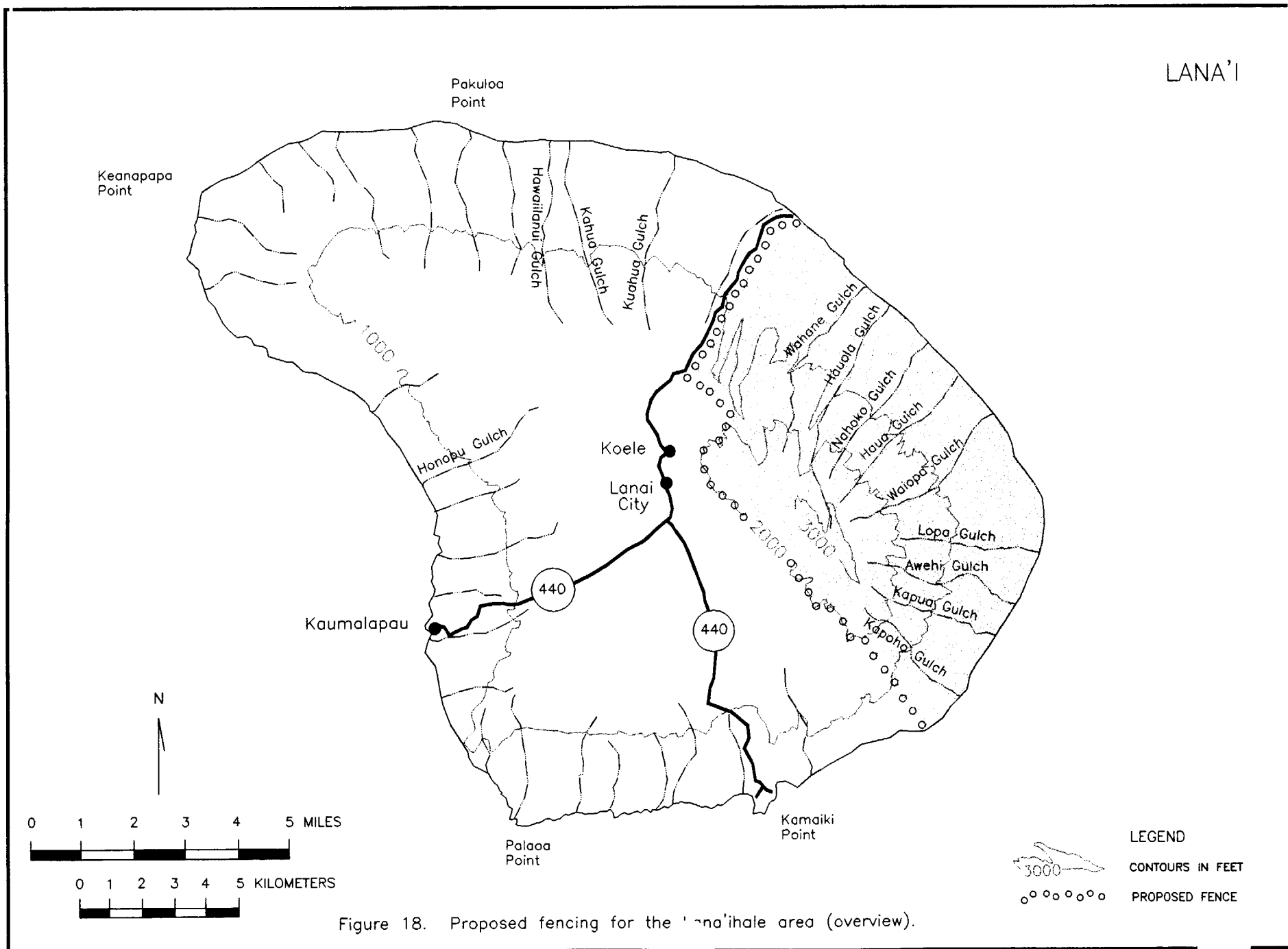


Figure 18. Proposed fencing for the 'ana'ihale area (overview).

The third option, small exclosures around some or all of the 40 management sites, could be useful in providing short-term protection for

the designated taxa. That would provide direct protection for the selected taxa from browsing and grazing of introduced ungulates as well as surrounding native vegetation. By removing ungulate disturbance on surrounding vegetation, the invasion of fenced habitats by alien species would likely be reduced. Even "small" exclosures are recommended to be designed with a minimum area sufficient to offset the negative impacts of the actual fencing and fence and site maintenance (e.g. scarification of fenceline and adjacent area and potential introduction of new pests into the area). An absolute minimum-sized exclosure should have its perimeter located at least 50 meters (164 feet) distant from the nearest individual of the target species. This distance should be viewed as a general guideline. Some practical suggestions regarding implementation of such plans are: 1) in some cases, several taxa/populations could be protected together in a single exclosure to concentrate initial fencing and later management efforts (possible groupings listed in Table 4); 2) fences should include, if possible, the target populations and a buffer area of good-quality, hopefully similar habitat for potential replanting efforts (and/or native buffer habitat such as stands of Dicranopteris, if present, that are resistant to invasion of alien species); 3) exclosures should focus on protecting small valley drainage systems versus constructing "postage stamp" exclosures around populations. Fences should be constructed along ridgelines and tied into streamcourses at natural barriers (such as the tops of waterfalls). Such design will reduce subsequent maintenance. Such small exclosures should be construed as stop-gap measures for short-term protection while longer-term plans to protect native habitats are designed and implemented. An advantage of such fencing if done carefully, possibly used in conjunction with another larger-scale fencing option, would be to provide immediate protection of vulnerable populations from direct damage by ungulates. Additionally, such fences would create manageable-sized units for weed control.

1212. Implement fencing and maintenance strategy for Lana'ihale areas.

Once the best method for fencing these sites is determined, fencing and maintenance plans should begin as soon as possible. All Lana'i fences should be impervious to axis deer, mouflon and pigs. It has been suggested that fences as high as 2.1 meters (7 feet) may be insufficient to

exclude axis deer, especially when they are excited, as when they are being hunted (R. Hobdy, personal communication 1992). That is particularly relevant since deer will undoubtedly be hunted on the outer periphery of the proposed fences. Final fencing layout must by necessity be determined by onsite inspection, but the entire areas outlined must be protected. Placement of fencing will be critical, particularly in areas of steep slopes. Effective deer guards (similar in concept to cattle guards) should be constructed on all roads crossed by fences. Fencing the Lana'ihale areas would provide protection to Cyrtandra munroi and Cyanea macrostegia ssp. gibsonii.

If small scale fencing is to be done before or instead of large scale fencing of the entire area, the following smaller areas should receive high priority for fencing: the upper portions of Hauola Gulch and the upper drainages of Maunalei (Wai'alala, Kunoa etc.), the upper portions of Waiapa'a and Kapōhaku drainages, taking advantage of ridge lines as much as possible, Awehi Gulch, the upper portions of any gulch where Phyllostegia glabra var. lanaiensis has historically been found, any gulch where Phyllostegia glabra is currently found and has not been positively identified as to variety, and the summit ridge of Lana'ihale in conjunction with fencing of individual drainages.

Ongoing inspection and maintenance of fences is necessary to ensure the continued exclusion of ungulates from the fenced areas.

1213. Determine fencing strategy for lowland areas of Lana'i.

Whereas the Lana'ihale species can best be protected by fencing a large area, the endangered species of dryland areas can probably be adequately addressed using relatively small enclosures (several hectares each). In arid areas, one advantage of such enclosures is the natural fuel breaks often formed at their peripheries by grazing and browsing activities. (Again, consideration must be made for experimental and/or modified methods for Abutilon menziesii) Plans for fences around populations discovered outside fenced areas should be made by field biologists if and when such populations are discovered. (Known lowland populations of Santalum freycinetianum var. lanaiense at Kanepu'u are already fenced.)

12131. Develop a fencing strategy for Lana'i Abutilon menziesii populations.

The downlisting objective of this plan calls for the protection of five to seven populations of each taxa on Lana'i. The delisting objective calls for the protection of 8 to 10 populations. An evaluation of the six A. menziesii populations on Lana'i (sites 4-9), should be done to develop a fencing strategy for this species on Lana'i. Factors such as access, topography, landowner preference and size and vigor of populations should be taken into consideration in developing this strategy.

12132. Implement fencing of Lana'i Abutilon menziesii populations.

Once the sites have been chosen, fencing and plans for maintenance should begin.

12133. Fence Tetramolopium remyi population.

The single T. remyi population (site #1) should be fenced immediately since the two individuals there are the only remaining members of this species and are under imminent threat from ungulates.

12134. Fence Abutilon eremitopetalum population.

The single A. eremitopetalum population (site #3) should be fenced immediately since the seven individuals there are the only remaining members of this species and are under imminent threat from ungulates. Robert Hobdy (personal communication 1992) estimates that initial fencing and weed control for Abutilon eremitopetalum could be done by volunteers in several days for about \$5000, including materials and helicopter time. Abutilon eremitopetalum plants occupy an area of about an acre. After fencing, monitoring must be timely and efforts to reverse any negative effects should be performed quickly. It is crucial that fencing, alien plant removal, and monitoring be done in conjunction with one another.

1214. Determine fencing strategies for Maui.

Fencing strategies for populations on Maui, including Santalum, Abutilon menziesii, and Cyrtandra, need to be determined and implemented, including appropriate followup actions.

12141. Develop a fencing strategy for Maui *Abutilon menziesii* populations to protect.

The downlisting objective of this plan calls for the protection of five to seven populations, at least one of which must be on another island where the species occurred. The delisting objective calls for the protection of 8 to 10 populations on Lana'i and at least 1 other island where the species occurred. A decision on which of the *A. menziesii* populations (sites 32-36 in table 4) to fence and manage will have to be made. Factors such as access, topography, landowner preference and size and vigor of populations should be taken into consideration in making this decision.

12142. Implement fencing of Maui *Abutilon menziesii* populations.

Once the sites have been chosen, fencing and plans for maintenance should begin.

12143. Fence Maui *Cyrtandra munroi* population.

The single *C. munroi* population on Maui (site 37) should be fenced immediately since the 30+ individuals there are the only remaining members of this species on Maui and are threatened by ungulates.

12144. Determine need to fence *Santalum* sites on Maui.

The remaining *Santalum* individuals on leeward East and West Maui (sites 38 and 39) are in extremely inaccessible areas and may not need to be fenced in order to protect them from ungulates. However, some vulnerable individuals may exist, and an evaluation of the need for fencing should be conducted.

12145. Fence *Santalum* individuals on Maui, if needed.

Implement fencing and maintenance plans for *Santalum* individuals on Maui, based on the outcome of task # 12144.

1215. Determine fencing strategies for Hawai'i.

Fencing strategies for the *Abutilon menziesii* population on Hawai'i need to be determined and implemented, including appropriate followup maintenance.

12151. Determine need for fencing on Hawai'i.

The single Abutilon menziesii population at Puako (site 40) should be evaluated and a decision on the need for fencing should be made.

12152. Fence Abutilon menziesii individuals on Hawai'i, if needed.

Implement fencing and maintenance plans for A. menziesii individuals on Hawai'i, based on the outcome of task # 12151.

1216. Remove ungulates within fenced areas.

If large areas are fenced, it will be necessary to remove ungulates from within the fenced areas. In all cases it is critically important to realize and act on the fact that habitat disturbance by hunting or snaring activities can be highly detrimental to the fragile ecosystems of Hawai'i. Direct damage to the environment as well as the possibilities of introduction of seeds of invasive alien plants and the creation of inroads for remaining ungulates and subsequent pathways for invasion of alien plants are of major consequence in such areas. Eradication options would include baited hunting, snaring, and poisoning. Also, hunting from helicopters is a highly effective method for ungulate eradication, particularly for situations such as that in the Lana'ihale area. Hunters and others who will be working in the habitat of the Lana'i cluster taxa should be appraised of the existence and whereabouts of the plants so that they do not inadvertently damage them.

1217. Monitor fenced areas for ungulates.

Ongoing monitoring for ungulates within the large fenced areas is necessary to ensure the continued absence of ungulates.

1218. Determine effects of excluding ungulates.

Experimental fencing is needed for the Lana'i cluster taxa to determine the effects of exclusion of ungulates, since their herbivory may have a more dramatic impact on invasive alien plants than on the endangered taxa. It is possible that without browsing by ungulates (until other management efforts can be devised and implemented) the present abundance of alien plants could quickly overwhelm some of the endangered taxa. These studies will be particularly important for Abutilon

eremitopetalum and should examine the effects of human activity in proximity to the plants.

122. Develop and/or support feral herbivore removal programs.

Ideally, island-wide programs to eradicate feral herbivores should be instigated and supported on Lana'i and other islands where the Lana'i cluster taxa occur. Fences are a maintenance-intensive and not altogether foolproof method of protecting habitats (Stone 1992) necessary for the perpetuation of the Lana'i cluster taxa. Ultimately, the eradication of feral herbivore populations on Lana'i and other islands (particularly axis deer and mouflon) is the only way to completely eliminate these threats to the Lana'i cluster taxa. Such removal of feral ungulates will slow down the degradation of watershed lands. However, public support of hunting on Lana'i is very fervent and the likelihood of acceptance of an ungulate eradication program seems remote.

123. Conduct essential alien plant control.

One of the most important aspects of habitat management for the Lana'i cluster taxa is the control of alien weeds. In all cases it is critically important to realize and act on the fact that habitat disturbance by weed removal activities can be highly detrimental to the fragile ecosystems of Lana'ihale. Direct damage to the environment as well as the possibilities of introduction of seeds of invasive alien plants and the creation of inroads for remaining ungulates and subsequent pathways for invasion of alien plants are of major consequence in such areas. Steps should always be taken to minimize these effects.

1231. Determine effective control methods.

For each negative effect known or discovered for any introduced species, effective control methods should be ascertained.

1232. Implement weed control.

Weed control should be aggressively implemented in the vicinity of the Lana'i cluster taxa, particularly within fenced areas. Control methods may include hand-pulling and possibly local herbicide application in some cases. Weed control should begin immediately for each population beginning with the immediate vicinity of the existing plants and continuing until control is achieved in the full management site. Followup visits to each site are necessary to ensure that weeds are controlled. Weed control must be ongoing; sites should be monitored periodically to determine when additional intervention is necessary.

Control efforts should be supervised by a botanist experienced in safe control methods to insure that crews do not compact soil, damage root systems or improperly apply herbicides. Also, care should be taken to protect associated native species, as well as the endangered species, during weed removal.

12321. Implement weed control for Lana'ihale sites.

As with fencing, weeding of the Lana'ihale sites (sites 10-31) is best done as a single, well coordinated effort. Control of weeds in the entire area will provide suitable areas for expansion of current populations and re-establishment of new populations within the species' historical ranges. This effort is far superior to the small, unconnected pockets of control that would result if the sites were treated separately.

Populations of Cyanea macrostegia ssp. gibsonii are under intensive stress from alien plant invasion (such as Kahili ginger (Hedychium garnerianum)) (R. Hobdy, personal communication 1992); alien plant control for this taxon is essential to alleviate this pressure, and these sites should be among the first tackled in the overall Lana'ihale weed control effort.

12322. Implement weed control for the Lana'i Abutilon menziesii populations.

Weeding should be done in each of the five sites chosen for fencing in task # 12131.

12323. Implement weed control for the Tetramolopium remyi population.

Weeding should begin immediately for the single T. remyi population (site 1), especially for Panicum maximum (currently within 30 meters of the only known population of Tetramolopium remyi).

12324. Implement weed control for the Abutilon eremitopetalum population.

Weeding should begin immediately for the single A. eremitopetalum population (site 3).

12325. Implement weed control efforts for Kanepu'u Santalum site.

Weed control for the Santalum site at Kanepu'u (site 2) should be coordinated with The Nature Conservancy's management program.

12326. Implement weed control for the Maui Abutilon menziesii populations.

Weeding should be done in each of the five sites chosen for fencing in task # 12141.

12327. Implement weed control for the Maui Cyrtandra munroi population.

Weeding should begin immediately for the single C. munroi population on Maui (site 37).

12328. Implement weed control for the E. Maui Santalum site.

Weed control for the E. Maui Santalum individuals (site 38) should be implemented where needed.

12329. Implement weed control for the W. Maui Santalum site.

Weed control for the W. Maui Santalum individuals (site 39) should be implemented where needed.

123210. Implement weed control for the Abutilon menziesii individuals on Hawai'i, if needed.

Implement weed control for the A. menziesii individuals on Hawai'i (site 40), based on the outcome of the evaluation done in task # 12151.

1233. Prevent introduction of new alien species to Hawai'i.

Introduction of alien weeds to the State of Hawai'i and between islands needs to be halted to prevent further threats to the Lana'i cluster taxa and their habitats. In order to prevent the introduction of new alien species, support should be given to programs or activities that limit the possibility of future introductions of alien species. The success of such programs or activities would contribute not only to the perpetuation of the endangered species in this plan, but to the quality of all native ecosystems as well as agricultural concerns in the State of Hawai'i.

Strengthening of the quarantine process upon entry to the State of Hawai'i and between

Hawaiian islands is essential to limit the number of intentional or accidental introductions of exotic species. More effective quarantine procedures, additional quarantine facilities, additional and well-trained personnel, adherence to correct protocols, and restricting incoming international traffic to existing entry points are necessary to facilitate this end.

Programs and/or campaigns to heighten public awareness of noxious weeds can also be beneficial and can develop the community support crucial to the success of this mission. As potential noxious weeds are recognized based on research or observation in other parts of the world, such pests should be quickly added to Hawai'i's list of noxious weeds (which are illegal to import to or possess in the State) and measures should be taken to prevent their introduction to the State (and consequently possibly to areas that could affect the Lana'i cluster taxa).

Efforts to support research and careful screening of exotic plants and animals proposed for importation and/or introduction should be supported to prevent future problems with such species.

124. Provide necessary fire protection.

The Lana'i cluster taxa are not well-adapted to survive fire, particularly those fires fed by unnatural buildup of fuel (such as that provided by the growth of alien grasses). In addition, many introduced plant species (such as fountain grass) are better adapted to recovery after fires and often invade burned areas radically, permanently changing the habitat. Protection from fire is critical to the survival of the endangered Lana'i cluster plants. Protection must be both local and on a larger scale in order to prevent fires from spreading to areas where the plants grow.

1241. Develop fire protection plans.

Plans to protect each site from fire should be developed. Fire represents one of the most profound threats to many of the Lana'i cluster taxa. Particularly in remote wilderness areas, fire protection plans and other infrastructure are critical. Public education regarding the prevention and consequences of fires should be undertaken. "Fire-free" zones should be established, with hunters and other land users apprised of the dangers of smoking and open flames in sensitive areas (i.e. any dry areas). Firebreaks with a minimum width of 6 meters (20 feet) should be constructed around fire prone populations of the Lana'i cluster plants wherever feasible. This minimum width may not

be sufficient to protect populations from fire in especially dry conditions.

1242. Implement fire protection plans.

Implement the plans developed in task # 1241.

125. Control predation and disease.

Threats not already addressed include predation by rodents and possibly more host-specific pests. Monitoring and control of such pests should be implemented.

1251. Control rodents.

Control rodents as needed to allow reproduction of endangered plant taxa. For Santalum freycinetianum var. lanaiense and Cyanea macrostegia ssp. gibsonii, and possibly for other taxa, measures need to be taken as necessary to control rodent damage to the endangered plants and their fruits and seeds to allow reproduction of the plants. Intensive rodent control over a period prior to and during fruit production is recommended for at least one season or until a good production season occurs, in order to have a viable crop of seeds for collection and ex situ propagation. (It has been noted that a "boom" in rodent populations often occurs immediately after such intensive control efforts are terminated [R. Hobdy, personal communication 1992]; however, it is deemed more important to do what is necessary to obtain viable seeds of the affected Lana'i cluster taxa than to attempt long-term reduction in rodent populations at this time.) Adequate approved methods for rodent control in Hawaiian ecosystems have not been developed; continuing research on such methods should be encouraged. Poisoning and/or trapping of rodents may be used as control methods if deemed appropriate by biologists involved. Additionally, rat barriers should be used where appropriate (e.g. Santalum freycinetianum var. lanaiense).

12511. Control rodents at Kanepu'u.

A rodent control program for the Santalum site at Kanepu'u (site 2) should be implemented in cooperation with TNC.

12512. Control rodents at Lana'ihale site.

Since both Santalum and Cyanea macrostegia ssp. gibsonii occur over most of the Lana'ihale area, an overall rodent control effort for the area will be more effective than a site-by-site program. Area wide control measures should begin as soon as possible.

12513. Control rodents at E. Maui Santalum site.

A rodent control program for the E. Maui Santalum individuals (site 38) should be implemented.

12514. Control rodents at W. Maui Santalum site.

A rodent control program for the W. Maui Santalum individuals (site 39) should be implemented.

12515. Control rodents in other areas, if needed.

If rodent predation on other species/areas is discovered, control programs should be implemented.

1252. Control Chinese rose beetle (Adoretus sinicus) as needed.

For Abutilon menziesii and Abutilon eremitopetalum, if the Chinese rose beetle is observed on these plants, it must be controlled to prevent damage to the plants. The degree of threat determined by research and field observations should determine the urgency of implementation of control measures. After effective control measures for the Chinese rose beetle are determined by research, an ongoing program of implementation and monitoring should be established.

1253. Control hibiscus scale as needed.

For Abutilon menziesii (and Abutilon eremitopetalum, if hibiscus scale is observed on these plants), hibiscus scale must be controlled to prevent damage to the plants. The degree of threat determined by research and field observations should determine the urgency of implementation of control measures. After effective control measures are determined by research, an ongoing program of implementation and monitoring should be established.

1254. Control spike disease as needed.

Spike disease must be controlled if it is deemed to be a threat to Santalum freycinetianum var. lanaiense. The degree of threat determined by research and field observations should determine the urgency of implementation of control measures. After effective control measures for spike disease are determined by research, an

ongoing program of implementation and monitoring should be established.

1255. Control Santalum heart rot as needed.

Santalum heart rot must be controlled if it is deemed to be a threat to Santalum freycinetianum var. lanaiense. The degree of threat determined by research and field observations should determine the urgency of implementation of control measures. After effective control measures for heart rot are determined by research, an appropriate ongoing program of implementation and monitoring should be established.

1256. Control Santalum seed fungus as needed.

Santalum seed fungus must be controlled if it is deemed to be a threat to Santalum freycinetianum var. lanaiense. The degree of threat determined by research should determine the urgency of implementation of control measures. After effective control measures for the Santalum seed fungus are determined by research, an appropriate program of implementation and monitoring should be established.

126. Ensure availability of pollination vectors.

Based on research findings, measures should be established to ensure that pollination vectors remain available to the Lana'i cluster taxa. If it is discovered that pollination vectors for certain taxa are in fact missing, necessary measures should be taken to compensate for these.

1261. Ensure that natural pollination vectors remain available.

Measures necessary to ensure the availability of natural pollination vectors must be determined and executed.

1262. Compensate for missing pollination vectors.

If natural pollination vectors are determined to be missing or in inadequate supply, measures necessary to ensure the availability of alternate pollination vectors must be determined and executed.

127. Protect areas from potential direct threats from humans.

Areas where the Lana'i cluster taxa grow should be protected as much as possible from hikers, vehicles, and other possibilities of direct human disturbance. As a part of protection of areas from human use, public awareness and education regarding these endangered taxa should be fostered. Public education

programs should be instigated, perhaps in conjunction with programs designed for other listed species. Other programs of public education regarding rare species and protection of native habitat should also be supported.

Signs designating sensitive environmental areas and/or research areas should be placed near sites where human contact may occur. "Kapu/No Trespassing" signs should prohibit entry to these areas. Such regulations should be strictly enforced by appropriate Federal and State agencies. If hiking is permitted, it is suggested that hikers must first be granted permission from the appropriate authority. This authority should be responsible for apprising hikers of the presence of sensitive environments and precautions that should be taken to avoid disturbance of such areas (e.g. cleaning of boots and clothing, the importance of staying on existing trails). Based on the specific situation, such signs may not be necessary for some populations that are in remote areas and/or areas not frequently visited. Signs may attract undue attention to these populations thereby exposing them to vandalism. Again, the decision regarding sign placement depends on the circumstances surrounding each population.

Where possible, roads and/or trails that pass through habitat of the Lana'i cluster taxa should be rerouted or closed to prevent ready access to these areas. In cases where that is not feasible (e.g. the Munro Trail), care should be taken at any time during road or trail maintenance in or near habitat of the endangered taxa to avoid practices that would cause excessive erosion or other damage to the Lana'i cluster plants or their habitat; all such activities should be closely monitored by an appropriate conservation agency.

Public awareness of the existence and significance of these taxa (and other endangered species) should be encouraged. Literature (such as pamphlets) should be made available to the public explaining the significance of and problems faced by rare species to increase public knowledge and support of the plight of these species. Such projects relevant to the Lana'i cluster taxa could be approached in conjunction with programs for other endangered or threatened species in the state. Exhibits could be developed portraying each of the Lana'i cluster taxa along with the problems they are facing. Possible solutions could be presented to each obstacle to their survival as well as information regarding prevention of such problems. These exhibits could be created separately or in conjunction with educational materials regarding other endangered species. Such exhibits should be made available to schools, museums, fairs, and other organizations for educational purposes.

Information should be made available to visitors to areas where the Lana'i cluster taxa grow regarding the presence and significance of these plants both

biologically and relative to their importance as part of Hawaiian heritage. Specific site locations should not be disclosed, however, to discourage overvisitation of sites and potential collection of or damage to plants or their habitats.

The Lana'i cluster taxa could be cultivated in garden settings with interpretive information at hand to allow visitors to learn about and actually see the plants without the necessity of visiting natural sites. Mention could be made of conservation efforts underway and the past, current, and projected status of the natural populations.

128. Monitor status of wild populations.

Wild populations of all the Lana'i cluster 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 Lana'i cluster taxa. Permanent plots around every occurrence of each taxon should be set up and mapped by size class 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. Each population of each taxon should be monitored periodically. Information such as changes in numbers of plants by size class, changes in vigor of individual plants, and changes or disturbances to the environment should be noted as appropriate and that data recorded. "Medium intensity" monitoring as outlined by Dunn (1992) is appropriate for all the Lana'i cluster taxa. In addition to normally-scheduled field checks, populations should be checked after any possible catastrophe or other unusual event by which they may have been affected. For certain taxa that may require experimental exclosures to determine effects of removal of herbivore pressure, methods similar to Dunn's (1992) "high intensity" monitoring are in order within the experimental and control plots.

129. Maintain genetic stock ex situ.

Cultivated populations of each Lana'i cluster taxon should be maintained in order to establish pools of genetic resources for reintroduction to appropriate sites and to safeguard against loss of the material due to catastrophe in wild populations. It should be noted, however, that cultivation of these plants is not a substitute for their preservation in the wild. Additionally, the existence of cultivated plants may reduce any demand for field-collected specimens of these rare taxa by providing a propagated source of

those taxa for which there might be a horticultural demand as ornamentals (e.g. Abutilon menziesii or other taxa desirable simply because of their rarity).

As broad a complement as possible of the existing genetic stock for each taxon should be preserved. Genetic material from each population should be preserved as appropriate for each situation. 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. In instances where certain methods are deemed to be inappropriate for certain taxa or populations (e.g. Tetramolopium remyi), alternate methods of obtaining genetic material should be implemented. All collected materials should be labelled accurately as to exact origin, collection date, etc.

Seeds of all the Lana'i cluster taxa should be collected and entrusted to seed banks for long-term storage using the best available techniques for preservation. Seeds in long-term storage should be periodically tested for viability and recollected as necessary.

A plan for seed collection should be developed for each of the Lana'i cluster taxa based on information regarding population sizes, fecundity of individual plants, and the current condition of occurrence sites. Material (along with applicable collection data) should be obtained from as many sites as feasible (if such collection is not deemed to have an adverse effect on each population) in order to maintain the broadest possible complement of genetic stock. Any preparation needed for seed collection should be included in the seed collection plans.

Collections of living plants of each of the Lana'i cluster taxa should be maintained. The origin of materials for such collections may be seeds, vegetative propagules, or plants from tissue culture. It is possible that in a very few generations in cultivation, selective pressures quite different than those in natural settings can affect the overall genetic makeup of the population. Therefore, material that is destined for reintroduction to wild areas should be cultivated under conditions that resemble as closely as possible what we know as natural conditions. When possible, it is best to use first (or second) generation progeny from wild-collected plants as material for reintroductions. These concerns emphasize the importance of documentation of lineage and cultivation conditions for all cultivated plants.

A schedule of monitoring for each cultivated collection of the Lana'i cluster plants should be prepared and adhered to. In addition, as new populations are discovered, arrangements for

nondestructive collection of material from each new population for cultivation and propagation should be made.

Tissue culture may be a useful method to preserve genetic material from some or all of the endangered Lana'i cluster taxa. This potential should be explored for each taxon. Plants to be cultured should be selected and meristem tissue collected from each only after having set up facilities to receive such material. Tissue from cultivated plants from first-generation seed could also be used.

2. Conduct essential research.

Research into various aspects of the life history, habitat, pollinators, reproductive biology, symbionts, optimum requirements for growth, requirements for population viability, and control of threats to each of the Lana'i cluster taxa must be carried out to better understand the requirements necessary for perpetuation of these plants. Such additional knowledge would 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.

Tetramolopium is a particularly important plant group for study because of the recent loss of diversity in the genus due to extinction of many species and limitation of ranges of others. For this species and other taxa with similar limitations of population size, it is important for as much living material as possible to be available for study. Ongoing research has been proposed for Tetramolopium remyi and other species in the genus including Tetramolopium capillare, a species federally listed as endangered.

21. Determine native versus alien status of questionable taxa.

Research should be undertaken to determine whether the plants on Lana'i referred to as Gahnia lanaiensis are actually Gahnia melanocarpa from eastern Australia or a related species (perhaps from New Zealand), or if Gahnia lanaiensis also exists elsewhere (e.g. Australia or New Zealand). If a taxon that is deemed to be the same taxon as Gahnia lanaiensis is found elsewhere, determination needs to be made, if possible, as to whether the Lana'i plants are indigenous or were introduced. If the plants on Lana'i are determined to be introduced, Gahnia lanaiensis should be removed from the Federal endangered species list and consideration should be given to removal of all plants now deemed Gahnia lanaiensis from the Lana'ihale area to prevent potential hybridization with Gahnia beecheyi (a Hawaiian endemic also on Lana'ihale).

22. Collect diagnostic data on crucial associated ecosystem components.

Composition of flora and invertebrate, bird, and other fauna populations within each plot should be established to attempt to gain an understanding of any relationships between these organisms and the Lana'i cluster plants.

Comparison of such information collected over time correlated with data from monitored populations of the Lana'i cluster taxa in known locations could provide insight into the required and/or preferred habitat for the endangered plants. Dunn (1992) suggests some possible monitoring techniques for these components of Hawaiian ecosystems.

23. Map alien vegetation.

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 Lana'i cluster plants occur. Advantages of aerial techniques include (1) the fact that such techniques are not directly invasive into the sensitive habitat of the endangered plants and that (2) large areas that may otherwise be inaccessible for observation may be monitored. Such mapping would allow changes in distributions and abundance of alien plants to be followed so that appropriate management actions may be taken.

24. 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.

25. Study reproductive viability.

Factors affecting the reproductive viability of each of the Lana'i cluster taxa need to be determined, including: breeding systems including self-compatibility; pollination vectors; and preferred conditions for flowering and seed set. This research will allow the best management strategy for each taxon to be developed.

26. 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.

27. Determine the degree of threats posed by and nature of interactions with selected diseases/introduced species.

The effects of introduced species on the Lana'i cluster taxa as well as the mechanisms of impact need to be determined in order to be able to better manage the endangered plants and their habitats.

271. Determine the degree of threat posed by the Chinese rose beetle (*Adoretus sinicus*) to *Abutilon eremitopetalum* and *A. menziesii*.

The degree of threat posed by the Chinese rose beetle needs to be determined by research into the life history of *Abutilon eremitopetalum* and *A. menziesii* in conjunction with field observations of the damage by this pest. Information gathered should become the basis for decisions regarding the urgency of implementation of control measures.

272. Determine the degree of threat posed by hibiscus scale to *Abutilon eremitopetalum* and *A. menziesii*.

The degree of threat posed by hibiscus scale needs to be determined by research into the life history of *Abutilon eremitopetalum* and *A. menziesii* in conjunction with field observations of the damage by this pest. Information gathered should become the basis for decisions regarding the urgency of implementation of control measures.

273. Determine the degree of threat posed by spike disease to *Santalum freycinetianum* var. *lanaiense*.

Since spike disease is suspected to affect Hawaiian sandalwoods (Hamilton and Conrad 1990), an assessment of the degree of threat posed to *Santalum freycinetianum* var. *lanaiense* is merited. Information gathered should become the basis for decisions regarding the urgency of implementation of control measures.

274. Determine the degree of threat posed by *Santalum* heart rot to *Santalum freycinetianum* var. *lanaiense*.

Since *Santalum* heart rot affects some Hawaiian sandalwoods (Merlin and VanRavenswaay in Hamilton and Conrad 1990), an assessment of the degree of threat (if any) posed to *Santalum freycinetianum* var. *lanaiense* is merited. Information gathered should become the basis for decisions regarding the urgency of implementation of control measures.

275. Determine the degree of threat posed by the reported seed viability-altering fungus to *Santalum freycinetianum* var. *lanaiense*.

Judd (1936) reported that in cultivation, a fungus, which may inhibit germination of seeds, exists in fly-damaged fruits of *Santalum freycinetianum*; such a fungus may impact the viability of seeds in wild situations as well. Research into the identity and effect of this fungus should be undertaken, as well as an assessment of the degree of threat (if any) posed to *Santalum freycinetianum* var. *lanaiense*. Information gathered should become the basis for

decisions regarding the urgency of implementation of control measures.

276. Determine mechanisms of impact of other diseases or pests.

If diseases or introduced pests with negative impacts on the Lana'i cluster taxa are discovered other than those listed, effects and mechanisms of each should be determined. Research into mechanisms of impact of alien species, including those listed in Part I, and any others that may be threats to the Lana'i cluster taxa, should be performed as deemed necessary by biologists or resource managers.

28. Determine effective control methods to combat selected diseases/introduced species.

Determination needs to be made of control methods to combat rodents, diseases and insects that do or may adversely affect the Lana'i cluster taxa.

281. Determine effective control methods for rodents.

Research into effective methods of rodent control for all taxa needs to be undertaken, ensuring that control measures do not adversely affect components of the native ecosystem. No currently approved predator control methods can adequately regulate populations of rats in Hawai'i (U.S. Forest Service 1992).

282. Determine effective control methods for the Chinese rose beetle (*Adoretus sinicus*) on *Abutilon eremitopetalum* and *Abutilon menziesii*.

If the Chinese rose beetle is determined to pose a threat to *Abutilon eremitopetalum* and/or *Abutilon menziesii*, research into effective control methods for the Chinese rose beetle on the appropriate *Abutilon* species should be undertaken, ensuring that the control measures do not adversely affect either *Abutilon* species.

283. Determine effective control methods for hibiscus scale on *Abutilon eremitopetalum* and *Abutilon menziesii*.

If the hibiscus scale is determined to pose a threat to *Abutilon eremitopetalum* and/or *Abutilon menziesii*, research into effective control methods for the hibiscus scale on the appropriate *Abutilon* species should be undertaken, ensuring that the control measures do not adversely affect either *Abutilon* species.

284. Determine effective control methods for spike disease on *Santalum freycinetianum* var. *lanaiense*.

If spike disease is determined to pose a threat to *Santalum freycinetianum* var. *lanaiense*, research into effective control methods for spike disease on

Santalum freycinetianum var. lanaiense should be undertaken.

285. Determine effective control methods for Santalum seed fungus on Santalum freycinetianum var. lanaiense.

If the Santalum seed fungus is determined to pose a threat to Santalum freycinetianum var. lanaiense, research into effective control methods for this pathogen on Santalum freycinetianum var. lanaiense should be undertaken.

286. Determine effective control methods for Santalum heart rot on Santalum freycinetianum var. lanaiense.

If Santalum heart rot is determined to pose a threat to Santalum freycinetianum var. lanaiense, research into effective control methods for this pathogen on Santalum freycinetianum var. lanaiense should be undertaken.

287. Other diseases and introduced pests.

If other diseases or introduced pests with negative impacts on the Lana'i cluster taxa are discovered, effective control methods for each should be determined.

288. Evaluate results and use in future management.

The results of the above studies should be evaluated and incorporated into the management process.

3. Expand existing wild populations.

In certain special instances, wild populations of the Lana'i cluster taxa may be augmented from cultivated propagules. This augmentation should be done conservatively and only after careful consideration of all factors involved. Any decision to augment existing populations should be made only when suitable habitat within the historical range of a taxon is not available and cannot reasonably be made available. Never should all existing populations be augmented; some populations should always remain intact without external introductions in case unforeseen problems occur after long latency. When making the decision to augment existing wild populations, it is particularly important to realize that it may not be possible to completely eliminate the possibility of introducing pests or pathogens; therefore, this option should be used only when other measures are not feasible. Decisions to augment populations should include consideration of concepts discussed at the conference, "Restoring Diversity: Is Reintroduction an Option for Endangered Plants?" (Missouri Botanical Garden, St. Louis, Missouri, April 20-22, 1993). This national conference, attended by a several Hawai'i conservationists, addressed the controversial topic of rare plant reintroduction, examining biological, political, and strategic considerations, as well as existing policies and reintroduction case studies. Ideas presented at the reintroduction conference may have relevance for decision-making for reintroduction strategies for the Lana'i cluster taxa. A book is due to be

published containing information from this conference; this book should be obtained and studied by recovery planners for the Lana'i cluster taxa. Augmentation efforts should always be well-documented as to lineage and methods.

31. Develop plans for expansion of each population.

The need for expansion of current populations should be evaluated, and specific plans should be created for the augmentation of wild populations that need to be enhanced.

311. Identify sites for expansion.

Sites of each taxon should be evaluated and determination made as to whether they are appropriate for addition of living material. The choice of sites should be based on the best information available in order to ensure the success of the endeavor. As new occurrences of each taxon are discovered, each new site should be evaluated for potential augmentation.

312. Identify material to be used for expansion.

For each selected site, material for expansion should be carefully chosen in order to best approximate the original material that exists or historically existed at the site to avoid genetic contamination of the population.

313. Determine optimum propagation methods.

Several methods are available that may be used to propagate these taxa. The most effective methods and techniques of propagating each taxon need to be determined. Any other propagation methods deemed suitable for these taxa should also be researched and used as necessary.

Potential, mechanisms, and/or preferred conditions for vegetative reproduction of each taxon should be explored both in terms of impact of such reproduction on wild populations and methods of cultivation of plants for possible wild population augmentation. Traditional soil- and water-based methods for vegetative reproduction should be examined as appropriate for each taxon.

Tissue culture should also be explored. This technique allows for the perpetuation of genetically identical clones from individual plants. Advantages to the tissue culture technique include the small amount of plant material necessary to begin each culture and the potential thereby presented to collect a set of material reflecting the total genetic diversity of entire populations, as well as presenting an often nondestructive method of collection of genetic material in many instances. For vigorous plants with multiple sites available for meristem tissue collection, the collection process often has few negative consequences. However, for small or weak

plants or those with only a single or a few possible points for meristem collection, the process can be traumatic or lethal. In addition, the introduction of pathogens is always a possibility. Care and good judgement are necessary.

A factor to be considered when tissue culture (or any other vegetative reproductive method) is used as a means of perpetuating germplasm is that the material being used is genetically identical. Such material should be reintroduced to wild populations sparingly so as not to bias the gene frequency or balance of gene combinations in wild populations, or--in the case of establishment of new populations--material from several to many clones may be introduced in one area to prevent immediate potential of extreme inbreeding.

A maintenance program should be established to ensure that cultures remain fresh. The central agency responsible for monitoring each taxon should prepare and adhere to a schedule of monitoring these cultures. Also, multiple cultures of each strain should be maintained, preferably at various locations, to ensure that a single disaster or contamination cannot eliminate any given strain. It is important to develop tissue culture techniques for these taxa not only to ensure their own perpetuation but so that baseline knowledge for tissue culture can be obtained regarding other similar taxa.

3131. Determine optimum propagation methods for *Abutilon eremitopetalum*.

See narrative under task # 313. Also, Since success has been reported with cuttings of *Abutilon menziesii* (K. Boche, personal communication 1992), using cuttings may be an option in addition to seeds for propagation of *Abutilon eremitopetalum*.

3132. Determine optimum propagation methods for *Abutilon menziesii*.

See narrative under task # 313. Also, propagation success has been reported with both seed (R. Hobdy, personal communication 1992; K. Boche, personal communication 1992) and cuttings (K. Boche, personal communication 1992) of *Abutilon menziesii*.

3133. Determine optimum propagation methods for *Cyanea macrostegia* ssp. *gibsonii*.

See narrative under task # 313.

3134. Determine optimum propagation methods for *Cyrtandra munroi*.

See narrative under task # 313.

3135. Determine optimum propagation methods for *Gahnia lanaiensis*.

See narrative under task # 313.

3136. Determine optimum propagation methods for *Phyllostegia glabra* var. *lanaiensis*.

See narrative under task # 313.

3137. Determine optimum propagation methods for *Santalum freycinetianum* var. *lanaiense*.

See narrative under task # 313. Also, most *Santalum* species can be propagated by seed; however, seeds of *Santalum freycinetianum* have sometimes failed to germinate, apparently due to a fungus that may have altered the viability of the seeds in fly-damaged fruits (Judd 1936). Some seed collection techniques have been described; it is evidently important to collect very fresh fruits (Richard Nakagawa, Maui DOFAW, personal communication 1992). It has been suggested that feeding sandalwood seeds to penned birds and using the passed seeds may be successful. Cuttings are not usually successful, but cleft grafting has had some success with at least one species of *Santalum*. Tissue culture has been successful for some *Santalum* species. Relevant recent information on cultivation research and methods was compiled during the 1990 Symposium on Sandalwood in the Pacific (e.g. Bule and Daruhi; Hirano; Neil; and Rai; in Hamilton and Conrad 1990).

3138. Determine optimum propagation methods for *Tetramolopium remyi*.

See narrative under task # 313. Also, tissue culture is not recommended for *Tetramolopium remyi* from wild populations at this time due to the small wild population size. Meristem from tissue culture should be obtained from first- or second-generation cultivated plants from seed. Seeds stored in soil are an important part of the long-term survival of annual species in extremely arid sites such as that. This species could be severely impacted by collection of all available seed.

3139. Determine optimum propagation methods for *Viola lanaiensis*.

See narrative under task # 313.

314. Determine appropriate reintroduction techniques.

Appropriate reintroduction techniques should be determined for each Lana'i cluster taxon based on findings of the conference "Restoring Diversity: Is Reintroduction an Option for Endangered Plants?" (Missouri Botanical Garden, St. Louis, Missouri, April 20-22, 1993) and principles for selection of sites and plant materials, site preparation, planting, and

monitoring. Such decisions should be conservative and carefully considered.

32. Implement expansion plans.

After sites are protected, add ex situ-propagated material to existing wild populations in quantities and times deemed appropriate based on population and growth studies. Only progeny from plants of the same site/population should be used to augment a population in order not to contaminate the existing local gene pool with genetic material from other origins. The goal of such augmentation is to allow a better chance for populations to survive in areas that they are known to occur naturally. However, augmentation of existing sites should be done only in special situations after careful consideration, since the risk of introduction of pathogens cannot be completely eliminated. All phases of augmentation operations should be adequately documented.

321. Propagate ex situ.

Ex situ propagation should be pursued for all taxa for augmentation of current populations, reintroduction to appropriate sites and to safeguard against loss of the material due to catastrophe in wild populations. Cultivation of these plants is not a substitute for their preservation in the wild. Each species should be propagated in numbers sufficient for its augmentation and reintroduction needs.

322. Prepare sites.

Each selected site must be prepared and protected appropriately, including the building of exclosures and exotic species control therein, as outlined above.

323. Plant.

The selected material should then be planted. Extreme care should be taken regarding the matching of soils if transplanting already-started plants due to differences in water retention around the root areas (i.e. if surrounding soil is more absorptive the soil directly around the roots could be overly dry and weaken or kill the newly-transplanted specimen).

324. Monitor and maintain new individuals.

Augmented populations should be monitored carefully. Ongoing maintenance of each site should occur after initial preparation and planting. The same protections and procedures regarding exclosures, ungulate removal, etc. should apply to new sites as have been recommended for existing sites. Any transplants that do not survive should be replaced.

4. Reestablish wild populations within the historic range.

If deemed appropriate, populations should be reestablished in areas where they are known to have occurred using cultivated propagules particularly if genetically uncontaminated, cultivated materials exist that originated from the historical site. The

goal of reintroduction of these taxa is to permanently reestablish viable populations of these taxa throughout their former ranges in stable and secure conditions for their perpetuation. Decisions to reestablish populations should include consideration of concepts discussed at the conference "Restoring Diversity: Is Reintroduction an Option for Endangered Plants?" (Missouri Botanical Garden, St. Louis, Missouri, April 20-22, 1993).

41. Investigate feasibility and desirability of reintroduction.

For each taxon, appropriateness of reintroduction of cultivated materials into wild situations should be assessed. Such reintroductions should be recommended conservatively and only after careful consideration of potential consequences. Genetic purity of populations is a prime concern, as are 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 methods in the designated information repository.

42. Develop specific plans for re-establishment.

Specific plans should be created for the reestablishment of wild populations of each of the Lana'i cluster taxa. Plans for each taxon should include documentation of all activities as well as the following general concepts.

421. Identify sites for re-establishment.

For taxa with very few extant sites, additional sites within the former range of the taxon should be identified for reintroduction of living material in order to meet the downlisting objectives. The choice of sites should be based on the best information available in order to match the site conditions to the requirements of the taxon.

In order to meet the downlisting objectives that call for five to seven populations of each taxon on Lana'i and at least one island where they formerly occurred, the following populations will have to be established: at least four populations of Abutilon eremitopetalum on Lana'i [perhaps on adjacent ridges and at sites more accessible to Lana'i City (for purposes of monitoring) and within the Kanepu'u preserve]; at least one population of Abutilon menziesii on Hawai'i or Oahu; at least one population of Cyrtandra munroi on Maui; at least one population of Gahnia lanaiensis on Lana'i; at least five populations of Phyllostegia glabra var. lanaiensis on Lana'i; at least four populations of Tetramolopium remyi on Lana'i and populations on Maui; and at least two populations of Viola lanaiensis on Lana'i. The status of Santalum freycinetianum var. lanaiense on Maui will have to be evaluated to determine how many populations should remain there before a decision to establish new populations is made.

422. Identify material to be used for re-establishment.

For each selected site, material for reintroduction should be carefully chosen in order to best approximate the original material that did or might have existed in the site previously to avoid genetic contamination of any nearby populations.

4221. Identify material for *Abutilon eremitopetalum* re-establishment on Lana'i.

See narrative under task # 422.

4222. Identify material for *Abutilon menziesii* re-establishment on Hawai'i and Oahu.

See narrative under task # 422.

4223. Identify material for *Cyrtandra munroi* re-establishment on Maui.

See narrative under task # 422.

4224. Identify material for *Gahnia lanaiensis* re-establishment on Lana'i.

See narrative under task # 422.

4225. Identify material for *Phyllostegia glabra* var. *lanaiensis* re-establishment on Lanai.

See narrative under task # 422.

4226. Identify material for *Tetramolopium remyi* re-establishment on Lana'i and Maui.

See narrative under task # 422.

4227. Identify material for *Viola lanaiensis* re-establishment on Lana'i.

See narrative under task # 422.

43. Implement re-establishment plans.

Plans prepared for the reestablishment of populations should be implemented. Ensure that selected materials are free from pests, diseases, and pathogens that might be introduced to the new or nearby wild populations. This aspect is particularly critical since cultivated plants may have been grown in the presence of other pathogen-carrying plants, and nearby wild populations may have lower resistance to such introductions.

431. Secure re-establishment sites.

Each of the sites chosen in task # 421 should be protected through cooperative agreements, conservation easements, leases or fee purchases negotiated with the landowners.

432. Prepare re-establishment sites.

Each selected site must be prepared and protected appropriately, including the building of exclosures and exotic species control therein, as outlined above.

433. Plant.

The selected material should then be planted. Extreme care should be taken regarding the matching of soils if transplanting already-started plants due to differences in water retention around the root areas (i.e. if surrounding soil in the transplant area is more absorptive than the soil used to start the plant, the roots could be overly dried and the newly-transplanted specimen could be weakened or could die).

434. Monitor and maintain new populations.

Introduced populations should be monitored carefully. Ongoing maintenance of each site should occur after initial preparation and planting. The same protections and procedures regarding exclosures, ungulate removal, etc. as have been recommended for existing sites should apply to new sites as well.

5. Validate recovery objectives.

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

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

For each of the Lana'i cluster taxa, a determination of the number of populations needed for long term survival should be made.

52. Refine/revise downlisting and delisting criteria.

Based on scientific information gathered during recovery efforts (e.g. data on viable population sizes), recovery criteria for each of the Lana'i cluster taxa should be revised to reflect rationally-based decisions regarding criteria for downlisting. Until such time as additional sound information is available, the criteria presented in this recovery plan should be used as the basis for downlisting.

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PART III. IMPLEMENTATION SCHEDULE

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

The actions identified in the implementation schedule, when accomplished, should protect habitat for these species, stabilize their existing populations and increase their population sizes and numbers. Monetary needs for all parties involved are identified to reach this point.

Priorities in Column 1 of the following Implementation Schedule are assigned as follows:

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

Key to Acronyms Used in Implementation Schedule

ES	-	Fish and Wildlife Service, Ecological Services, Honolulu, Hawaii
FWS-LE	-	Fish and Wildlife Service, Law Enforcement
USDA	-	U.S. Department of Agriculture
ACD	-	U.S. Department of Agriculture, Animal Damage Control
DLNR	-	Hawaii State Department of Land and Natural Resources
HDOA	-	Hawaii State Department of Agriculture
C&C	-	Castle & Cooke Land Co.
TNCH	-	The Nature Conservancy of Hawaii
HC&S	-	Hawaiian Commercial & Sugar Co.
HRC	-	Haleakala Ranch Co.
HH	-	Hawaiian Homelands
NH	-	Nansay Hawai'i
UR	-	Ulupalakua Ranch
NBS	-	National Biological Survey
MCFD	-	Maui County Fire Department
HCFD	-	Hawai'i County Fire Department
NTBG	-	National Tropical Botanical Garden, Kauai

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
Secure current populations:											
1	111	Identify all wild populations	3	* DLNR ES TNCH	15 3 3		5 1 1	5 1 1	5 1 1		
1	112	Identify areas for preservation	3	* DLNR ES TNCH	15 3 3		5 1 1	5 1 1	5 1 1		
1	1131	Protect habitat owned by Castle & Cooke Land Co.	2	* ES DLNR C&C TNCH	1 0.5 0.5 1		0.5 0.25 0.25 0.5	0.5 0.25 0.25 0.5			
1	1132	Protect habitat owned by Hawaiian Commercial & Sugar Co.	2	* ES DLNR HC&S	1 0.5 0.5		0.5 0.25 0.25	0.5 0.25 0.25			
1	1133	Protect habitat owned by Haleakala Ranch Co.	2	* ES DLNR HRC	1 0.5 0.5		0.5 0.25 0.25	0.5 0.25 0.25			

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
2	4227	Identify material for <u>V. lanaiensis</u> reestablishment	5	* DLNR	2.5		0.5	0.5	0.5	0.5	
				NBS	2.5		0.5	0.5	0.5	0.5	
				ES	2.5		0.5	0.5	0.5	0.5	
2	431	Secure reestablishment sites	2	* ES	20		10	10			
				DLNR	20		10	10			
				TNCH	20		10	10			
2	432	Prepare reestablishment sites	5	* DLNR	1000			200	200	200	
				ES	1000			200	200	200	
				TNCH	25			5	5	5	
2	433	Plant	10	* DLNR	2000						
				ES	2000						
				TNCH	50						
2	434	Monitor and maintain new populations	C	* DLNR	480						
				ES	480						
				TNCH	32						
		NEED 4 (Reestablish in former range)			7319.5	0	68.5	473.5	443.5	443.5	
Validate recovery objectives:											
3	51	Determine number of populations needed for long term survival	3	* NBS	9						
				ES	9						
				DLNR	9						

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	1134	Protect habitat owned by Nansay Hawai'i	2	* ES DLNR NH	1 0.5 0.5		0.5 0.25 0.25	0.5 0.25 0.25			
1	1135	Protect habitat owned by Ulupalakua Ranch	2	* ES DLNR UR	1 0.5 0.5		0.5 0.25 0.25	0.5 0.25 0.25			
1	1136	Protect habitat owned by the State of Hawai'i	2	* ES DLNR	1 0.5		0.5 0.25	0.5 0.25			
1	1137	Protect habitat owned by Hawaiian homelands	2	* ES HH DLNR	1 0.5 0.5		0.5 0.25 0.25	0.5 0.25 0.25			
1	114	Work with Hawaii to Enforce protection from development	0	* DLNR FWS-LE	22 22	1 1	1 1	1 1	1 1	1 1	Ongoing
Manage current populations:											
1	1211	Determine fencing for Lana'ihale area	2	* DLNR ES TNCH C&C	5 1 0.5 0.5		2.5 0.5 0.25 0.25	2.5 0.5 0.25 0.25			
1	1212	Implement fencing for Lana'ihale area	10	* DLNR ES C&C	200 200 50			20 20 5	20 20 5	20 20 5	

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	12131	Develop fencing strategy for Lana'i <u>A. menziesii</u> populations	2	* DLNR ES TNCH	5 1 0.5		2.5 0.5 0.25	2.5 0.5 0.25			
1	12132	Implement fencing for Lana'i <u>A. menziesii</u> populations	2	* DLNR ES C&C	40 40 10			20 20 5	20 20 5		
1	12133	Fence <u>T. ramyi</u> population	2	* DLNR ES C&C	20 20 4			10 10 2	10 10 2		
1	12134	Fence <u>A. eremitopetalum</u> population	2	* DLNR ES C&C	20 20 4			10 10 2	10 10 2		
1	12141	Develop fencing strategy for Maui <u>A. menziesii</u> populations.	2	* DLNR ES TNCH	5 1 0.5			2.5 0.5 0.25	2.5 0.5 0.25		
1	12142	Implement fencing of Maui <u>A. menziesii</u> populations	2	* DLNR ES HC&S HR	40 40 4 4				20 20 2 2	20 20 2 2	
1	12143	Fence Maui <u>Cyrtandra munroi</u> population	2	* DLNR ES	20 20			10 10	10 10		

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	12144	Determine need to fence <u>Santalum</u> sites on Maui	2	* DLNR ES TNCH	5 1 0.5			2.5 0.5 0.25	2.5 0.5 0.25		
1	12145	Fence Maui <u>Santalum</u> individuals, if needed	TBD	* DLNR ES UR	0 0 0			TBD TBD TBD			
1	12151	Determine need for fencing <u>A. menziesii</u> on Hawai'i	2	* DLNR ES	1 1			0.5 0.5	0.5 0.5		
1	12152	Fence Hawai'i <u>A. menziesii</u> , if needed	2	* DLNR ES NH	10 10 2				5 5 1	5 5 1	
1	1216	Remove ungulates from fenced areas	5	* DLNR ES C&C	150 75 25			30 15 5	30 15 5	30 15 5	
1	1217	Monitor fenced areas for ungulates	C	* DLNR ES C&C	100 20 10			5 1 0.5	5 1 0.5	5 1 0.5	
1	1218	Determine effects of excluding ungulates	5	* DLNR NBS	30 14			10 10	5 1	5 1	
1	122	Develop feral herbivore removal programs	2	* DLNR ES	10 2		5 1	5 1			

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	1231	Determine alien plant control methods	5	* DLNR NBS	120 120		30 30	30 30	30 30	30 30	
1	12321	Implement weed control for Lana'ihale sites	C	* DLNR ES C&C	740 470 56			100 100 10	100 100 10	30 15 2	
1	12322	Implement weed control for Lana'i <u>A. menziesii</u> populations	C	* DLNR ES C&C	56 56 18			10 10 2	10 10 2	2 2 0.5	
1	12323	Implement weed control for <u>T. remyi</u> population	C	* DLNR ES C&C	28 28 3.8			5 5 1	5 5 1	1 1 0.1	
1	12324	Implement weed control for <u>A. eremitopetalum</u> population	C	* DLNR ES C&C	28 28 3.8			5 5 1	5 5 1	1 1 0.1	
1	12325	Implement weed control for Kanepu'u <u>Santalum</u> site	O	* TNCH DLNR ES	40 20 20	10 5 5	10 5 5	1 0.5 0.5	1 0.5 0.5	1 0.5 0.5	
1	12326	Implement weed control for Maui <u>A. menziesii</u> populations	C	* DLNR ES HC&S HR	56 56 3.8 3.8			10 10 1 1	10 10 1 1	2 2 0.1 0.1	

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	12327	Implement weed control for Maui <u>C. munroi</u> population	C	* DLNR ES	28 28			5 5	5 5	1 1	
1	12328	Implement weed control for E. Maui <u>Santalum</u> site	C	* DLNR ES UR	112 112 28			20 20 5	20 20 5	4 4 1	
1	12329	Implement weed control for W. Maui <u>Santalum</u> site	C	* DLNR ES	112 112			20 20	20 20	4 4	
1	123210	Implement weed control for <u>A. menziesii</u> on Hawai'i, if needed	C	* DLNR ES NH	0 0 0			TBD TBD TBD			
1	1233	Prevent introduction of new alien species	O	* DLNR FWS-LE HDOA	44 44 44	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	Ongoing
1	1241	Develop fire protection plans	5	* DLNR ES MCFD HCFD TNCH	125 125 12.5 12.5 12.5		25 25 2.5 2.5 2.5	25 25 2.5 2.5 2.5	25 25 2.5 2.5 2.5	25 25 2.5 2.5 2.5	

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	1242	Implement fire protection plans	C	* DLNR ES MCFD HCFD TNCH	284 48 284 13 30			34 6 34 2 6	34 6 34 2 6	12 2 12 0.5 1	
1	12511	Control rodents at Kanepu'u	C	* DLNR ES TNCH	20 20 100			1 1 5	1 1 5	1 1 5	
1	12512	Control rodents at Lana'ihale site	C	* DLNR ES C&C	200 100 20			10 5 1	10 5 1	10 5 1	
1	12513	Control rodents at E. Maui <u>Santalum</u> site	C	* DLNR ES UR	60 30 6			10 5 1	10 5 1	10 5 1	
1	12514	Control rodents at W. Maui <u>Santalum</u> site	C	* DLNR ES	200 100			10 5	10 5	10 5	
1	12515	Control rodents in other areas, if needed	C	* DLNR ES	0 0			TBD TBD			
1	1252	Control Chinese rose beetle as needed	TBD	* DLNR ES	0 0			TBD TBD			
1	1253	Control hibiscus scale as needed	TBD	* DLNR ES	0 0			TBD TBD			

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	1254	Control spike disease as needed	TBD	* DLNR ES	0 0			TBD TBD			
1	1255	Control <u>Santalum</u> heart rot as needed	TBD	* DLNR ES TNCH	0 0 0			TBD TBD			
1	1256	Control <u>Santalum</u> seed fungus as needed	TBD	* DLNR ES TNCH	0 0 0			TBD TBD			
1	1261	Ensure that native pollinators remain available	C	* DLNR ES NBS	0 0 0			TBD TBD			
1	1262	Compensate for missing pollination vectors	TBD	* DLNR ES	0 0			TBD TBD			
1	127	Protect sites from potential direct threats from humans	C	* DLNR ES C&C TNCH HC&S HR UR	310 310 44 32 11 11 11			65 65 13 7 1 1 1	65 65 13 7 1 1 1	10 10 1 1 0.5 0.5 0.5	
1	128	Monitor status of wild populations	C	* DLNR ES TNCH	420 320 20			21 16 1	21 16 1	21 16 1	

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
1	129	Maintain genetic stock	O	* DLNR	120	10	10	5	5	5	
				ES	120	10	10	5	5	5	
				NTBG	300	50	50	10	10	10	
		NEED 1 (Secure and manage current sites)			7853.7	98	249.5	1117.5	1138.5	531.9	
Determine Essential Research:											
2	21	Determine native vs. alien status	2	DLNR	2		1	1			
				* ES	4		2	2			
				NBS	4		2	2			
2	22	Study associated ecosystem components	10	* NBS	300		30	30	30	30	
				DLNR	100		10	10	10	10	
2	23	Map alien vegetation	C	* DLNR	125		15	15	5	5	
				ES	39		10	10	1	1	
				TNCH	23		2	2	1	1	
2	24	Study growth	10	* NBS	150		15	15	15	15	
				ES	50		5	5	5	5	
				DLNR	150		15	15	15	15	
2	25	Study reproductive viability	10	* NBS	150		15	15	15	15	
				ES	50		5	5	5	5	
				DLNR	150		15	15	15	15	

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PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
2	26	Determine parameters of viable populations	10	* NBS ES DLNR	150 50 150		15 5 15	15 5 15	15 5 15	15 5 15	
2	271	Determine threat from the Chinese rose beetle	5	* DLNR ES HDOA	10 10 10		2 2 2	2 2 2	2 2 2	2 2 2	
2	272	Determine threat from hibiscus scale	5	* DLNR ES HDOA	10 10 10		2 2 2	2 2 2	2 2 2	2 2 2	
2	273	Determine threat from spike disease	5	* DLNR ES HDOA	10 10 10		2 2 2	2 2 2	2 2 2	2 2 2	
2	274	Determine threat from <u>Santalum</u> heart rot	5	* DLNR ES HDOA	10 10 10		2 2 2	2 2 2	2 2 2	2 2 2	
2	275	Determine threat from <u>Santalum</u> seed fungus	5	* DLNR ES HDOA	10 10 10		2 2 2	2 2 2	2 2 2	2 2 2	
2	276	Determine impact of other diseases/pests	TBD	* DLNR ES HDOA	0 0 0		TBD TBD TBD				

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PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
2	281	Determine control methods for rodents	5	* DLNR	150		30	30	30	30	
				NBS	150		30	30	30	30	
				ES	50		10	10	10	10	
				USDA	50		10	10	10	10	
				ADC	50		10	10	10	10	
2	282	Determine control methods for Chinese rose beetle	5	* DLNR	0				TBD		
				ES	0				TBD		
				HDOA	0				TBD		
2	283	Determine control methods for hibiscus scale	5	* DLNR	0				TBD		
				ES	0				TBD		
				HDOA	0				TBD		
2	284	Determine control methods for spike disease	5	* DLNR	0				TBD		
				ES	0				TBD		
				HDOA	0				TBD		
2	285	Determine control methods for <u>Santalum</u> seed fungus	5	* DLNR	0				TBD		
				ES	0				TBD		
				HDOA	0				TBD		
2	286	Determine control methods for <u>Santalum</u> heart rot	5	* DLNR	0				TBD		
				ES	0				TBD		
				HDOA	0				TBD		
2	287	Determine control methods for other diseases and pests	TBD	* DLNR	0				TBD		
				ES	0				TBD		
				HDOA	0				TBD		

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
2	288	Evaluate research results and use in future management	C	* DLNR ES NBS	190 190 190				10 10 10	10 10 10	
		NEED 2 (Conduct essential research)			2817	0	297	297	302	302	
Expand existing wild populations:											
2	311	Identify sites for expansion	5	* DLNR ES NBS	75 25 75		15 5 15	15 5 15	15 5 15	15 5 15	
2	312	Identify material to be used for augmentation	5	* DLNR ES NBS	25 5 25		5 1 5	5 1 5	5 1 5	5 1 5	
2	3131	Determine propagation methods for <u>Abutilon eremitopetalum</u>	10	* DLNR NTBG ES	150 150 50		15 15 5	15 15 5	15 15 5	15 15 5	
2	3132	Determine propagation methods for <u>Abutilon menziesii</u>	10	* DLNR NTBG ES	150 150 50		15 15 5	15 15 5	15 15 5	15 15 5	
2	3133	Determine propagation methods for <u>C. macrostegia</u> ssp. <u>gibsonii</u>	10	* DLNR NTBG ES	150 150 50		15 15 5	15 15 5	15 15 5	15 15 5	

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PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
2	3134	Determine propagation methods for <u>Cyrtandra munroi</u>	10	* DLNR	150		15	15	15	15	
				NTBG	150		15	15	15	15	
				ES	50		5	5	5	5	
2	3135	Determine propagation methods for <u>Gahnia lanaiensis</u>	10	* DLNR	150		15	15	15	15	
				NTBG	150		15	15	15	15	
				ES	50		5	5	5	5	
2	3136	Determine propagation methods for <u>P. glabra</u> var. <u>lanaiensis</u>	10	* DLNR	150		15	15	15	15	
				NTBG	150		15	15	15	15	
				ES	50		5	5	5	5	
2	3137	Determine propagation methods for <u>S. freycinetianum</u> var. <u>lanaiense</u>	10	* DLNR	150		15	15	15	15	
				NTBG	150		15	15	15	15	
				ES	50		5	5	5	5	
2	3138	Determine propagation methods for <u>Tetramolopium remyi</u>	10	* DLNR	150		15	15	15	15	
				NTBG	150		15	15	15	15	
				ES	50		5	5	5	5	
2	3139	Determine propagation methods for <u>Viola lanaiensis</u>	10	* DLNR	150		15	15	15	15	
				NTBG	150		15	15	15	15	
				ES	50		5	5	5	5	
2	314	Determine reintroduction techniques	5	* DLNR	750		150	150	150	150	
				NTBG	750		150	150	150	150	
				ES	250		50	50	50	50	

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PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
2	321	Propagate	0	* DLNR	1500	150	150	150	150	150	
				NTBG	1500	150	150	150	150		
				ES	500	50	50	50	50		
2	322	Prepare sites	5	* DLNR	0			TBD			
				ES	0			TBD			
				TNCH	0			TBD			
				C&C	0			TBD			
2	323	Plant	10	* DLNR	0				TBD		
				ES	0			TBD			
				TNCH	0			TBD			
				C&C	0			TBD			
2	324	Monitor and maintain new individuals	C	* DLNR	0				TBD		
				ES	0			TBD			
				TNCH	0			TBD			
				C&C	0			TBD			
	NEED 3 (Expand current populations)				8630	350	1061	1061	1061	1061	
Reestablish wild populations within historic range:											
2	41	Investigate feasibility and desirability of reintroduction	5	* DLNR	35		5	5	5	5	
				ES	5		1	1	1	1	
				NBS	5		1	1	1	1	

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
2	421	Identify sites for reestablishment	5	* DLNR	50		10	10	10	10	
				ES	5		1	1	1	1	
				NBS	50		10	10	10	10	
2	4221	Identify material for <u>A. eremitopetalum</u> reestablishment	5	* DLNR	2.5		0.5	0.5	0.5	0.5	
				NBS	2.5		0.5	0.5	0.5	0.5	
				ES	2.5		0.5	0.5	0.5	0.5	
2	4222	Identify material for <u>A. menziesii</u> reestablishment	5	* DLNR	2.5		0.5	0.5	0.5	0.5	
				NBS	2.5		0.5	0.5	0.5	0.5	
				ES	2.5		0.5	0.5	0.5	0.5	
2	4223	Identify material for <u>C. munroi</u> reestablishment	5	* DLNR	2.5		0.5	0.5	0.5	0.5	
				NBS	2.5		0.5	0.5	0.5	0.5	
				ES	2.5		0.5	0.5	0.5	0.5	
2	4224	Identify material for <u>G. lanaiensis</u> reestablishment	5	* DLNR	2.5		0.5	0.5	0.5	0.5	
				NBS	2.5		0.5	0.5	0.5	0.5	
				ES	2.5		0.5	0.5	0.5	0.5	
2	4225	Identify material for <u>P. glabra</u> var. <u>lanaiensis</u> reestablishment	5	* DLNR	2.5		0.5	0.5	0.5	0.5	
				NBS	2.5		0.5	0.5	0.5	0.5	
				ES	2.5		0.5	0.5	0.5	0.5	
2	4226	Identify material for <u>T. remyi</u> reestablishment	5	* DLNR	2.5		0.5	0.5	0.5	0.5	
				NBS	2.5		0.5	0.5	0.5	0.5	
				ES	2.5		0.5	0.5	0.5	0.5	

Recovery Plan Implementation Schedule for the Lana'i Plant Cluster

PRIORITY #	TASK #	TASK	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES (\$1,000'S)					Comments
						FY1994	FY1995	FY1996	FY1997	FY1998	
3	52	Refine/revise downlisting and delisting criteria	3	* ES DLNR	9 9						
		NEED 5 (Validate recovery objectives)			45	0	0	0	0	0	
TOTAL COST					26665.2	448	1676	2949	2945	2338.4	

APPENDIX A - Individuals Contacted During Plan Review

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Haleakala Ranch Co.
529 Kealaloa Ave.
Makawao, HI 96768

State of Hawaii
Dept. of Hawaiian Homelands
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Nansay Hawaii
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* - Comments were received

APPENDIX B

Site Specific Maps

Requests for appendix B will be considered on a case by case basis.

Requests should be directed to:

U.S. Fish and Wildlife Service
Pacific Islands Office
Brooks Harper, Field Supervisor
300 Ala Moana Blvd., Room 6307
Honolulu, HI 96850

APPENDIX C RECOVERY PRIORITY SYSTEM

The Species Recovery Priority System uses the criteria of (1) degree of threat, (2) recoverability, and (3) taxonomy [level of genetic diversity]. 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).

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