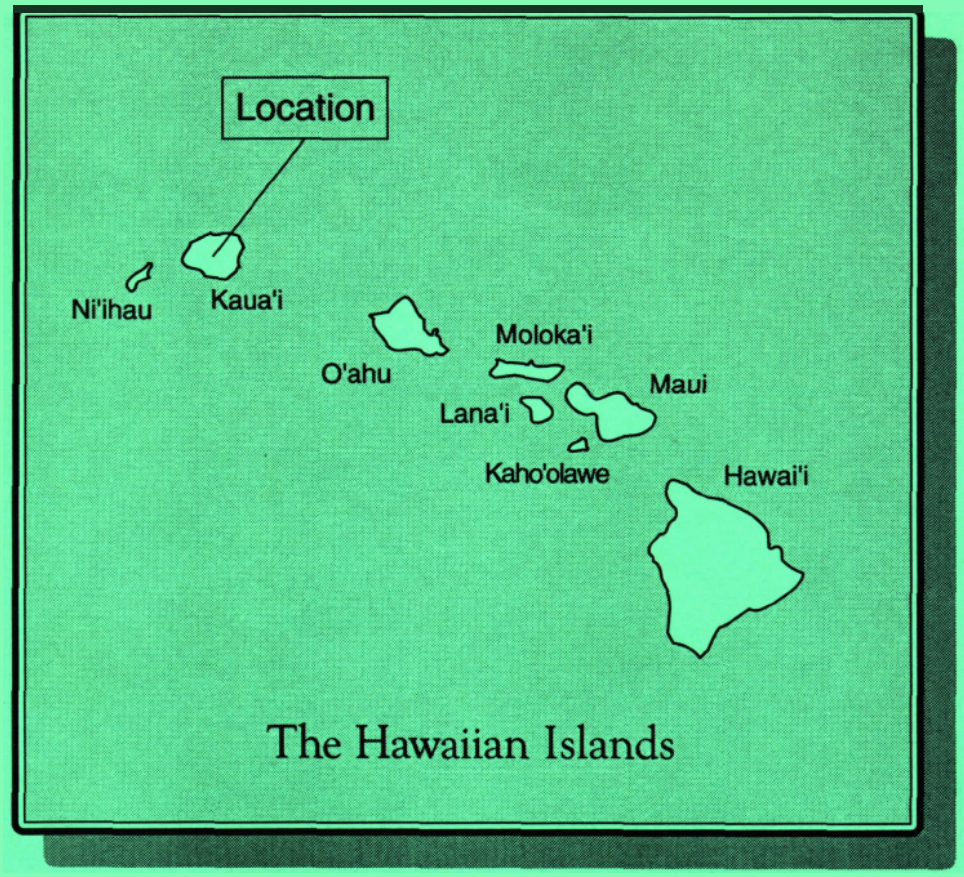
RECOVERY PLAN FOR THE KAUA'I PLANT CLUSTER

JULY, 1995



U.S. Fish and Wildlife Service, Pacific Region

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RECOVERY PLAN FOR THE

KAUAI PLANT CLUSTER

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EXECUTIVE SUMMARY

Current Species Status: This plan covers 37 plant taxa, 34 of which are federally listed as endangered and three of which are federally listed as threatened. The numbers of known remaining populations and individuals are as follows (# of populations, # of individuals): *Brighamia insignis* (olulu) (5, 60-70), *Chamaesyce halemanui* (akoko) (4, 96-151), *Cyanea asarifolia* (haha) (1, 4-5), *Cyrtandra limahuliensis* (haiwale) (12, 10,000), *Delissea rhytidosperma* (oha) (2, 19), *Diellia pallida* (no common name (NCN)) (3, 23), *Dubautia latifolia* (naenae) (11, >100), *Exocarpos luteolus* (heau) (12, 324-349), *Hedyotis cookiana* (awiwi) (1, 50-100), *Hedyotis st.- johnii* (NCN) (4, 200), *Hibiscus clayi* (kokio ulaula) (1, 4), *Lipochaeta fauriei* (nehe) (3, <70), *Lipochaeta micrantha* var. *exigua* (nehe) (2, 100-500), *Lipochaeta micrantha* var. *micrantha* (nehe) (2-4, 150-570), *Lipochaeta waimeaensis* (nehe) (1, >100), *Lysimachia filifolia* (NCN) (2, 170-275), *Melicope haupuensis* (alani) (1, 2), *Melicope knudsenii* (alani) (6, 24-34), *Melicope pallida* (alani) (6, 157), *Melicope quadrangularis* (alani) (1, 13), *Munroidendron racemosum* (NCN) (15, 200), *Nothocestrum peltatum* (aiea) (7, 23), *Peucedanum sandwicense* (makou) (16, 1,000-5,000), *Phyllostegia waimeae* (NCN) (no known current populations), *Poa mannii* (Mann's bluegrass) (5, 135), *Poa sandvicensis* (NCN) (4, <1,000), *Poa siphonoglossa* (NCN) (3, 42), *Pteralyxia kauaiensis* (kaulu) (9, 500-1,000), *Remya kauaiensis* (NCN) (18, <200), *Remya montgomeryi* (NCN) (2, 55-75), *Schiedea apokremnos* (NCN) (5, 600), *Schiedea spergulina* var. *leiopoda* (NCN) (1, 50-100), *Schiedea spergulina* var. *spergulina* (NCN) (5, >5,000), *Solanum sandwicense* (popolo aiakeakua) (4, 20), *Stenogyne campanulata* (NCN) (1, 50), *Wilkesia hobdyi* (dwarf iliau) (5, 420-510), and *Xylosma crenatum* (maua) (4, 13).

Distributions: Thirty of these taxa are either endemic to, or have their largest or best known populations on, the island of Kauai. The following taxa have historic and/or current populations on other islands as well as Kauai: *Brighamia insignis* on Niihau; *Hedyotis cookiana* on Hawaii (extinct), Molokai (extinct) and Oahu (extinct); *Lysimachia filifolia* on Oahu; *Melicope knudsenii* on Maui; *Melicope pallida* on Oahu (extinct); *Peucedanum sandwicense* on Maui, Molokai and Oahu; and *Solanum sandwicense* on Oahu.

Habitat Requirements and Limiting Factors: The 37 taxa included in this plan grow in a variety of vegetation communities (grassland, shrubland, and forests), elevational zones (coastal to montane), and moisture regimes (dry to wet). These taxa and their habitats have been variously affected or are currently threatened by one or more of the following: habitat alteration from agriculture, ranching and/or development; trampling, predation and

habitat degradation by introduced ungulates; habitat degradation and competition for space, light, water, and nutrients by naturalized, alien vegetation; fire; introduced birds; predation by rodents and slugs; illegal collecting and other human impacts; insects and disease; and loss of pollinators. Due to the small number of existing individuals and their very narrow distributions, these taxa and most of their populations are subject to an increased likelihood of extinction and/or reduced reproductive vigor from stochastic events.

Recovery Objectives: 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 Kauai cluster 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 Kauai, 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 Kauai 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 a minimum of five consecutive years before downlisting is considered.

Delisting Objectives

For delisting, a total of 8 to 10 populations of each taxon should be documented on Kauai 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 a minimum of five consecutive years.

Actions Needed:

1. Protect current populations, control threats and monitor.
2. Expand current populations.
3. Conduct research essential to conservation of the species.
4. Establish new populations as needed to reach recovery objectives.
5. Validate and revise recovery objectives.
6. Devise and implement a public education program.

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

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Total
1995	76.0	760.0	0.0	0.0	0.0	0.0	836.0
1996	340.5	1225.0	715.0	150.0	0.0	10.0	2430.5
1997	1274.4	1225.0	715.0	150.0	0.0	10.0	3364.4
1998	1333.4	1225.0	747.0	150.0	0.0	10.0	3455.4
1999	1223.9	1225.0	747.0	150.0	0.0	10.0	3345.9
2000	1223.9	1225.0	747.0	155.0	0.0	10.0	3350.9
2001	1031.4	760.0	627.0	0.0	0.0	0.0	2418.4
2002	949.8	760.0	627.0	0.0	0.0	0.0	2336.8
2003	907.8	760.0	627.0	0.0	0.0	0.0	2294.8
2004	907.8	760.0	627.0	0.0	0.0	0.0	2294.8
2005	907.8	0.0	627.0	0.0	0.0	0.0	1534.8
2006	907.8	0.0	77.0	0.0	0.0	0.0	984.8
2007	462.8	0.0	77.0	0.0	0.0	0.0	539.8
2008	380.8	0.0	77.0	0.0	0.0	0.0	457.8
2009	380.8	0.0	77.0	0.0	0.0	0.0	457.8
2010	380.8	0.0	77.0	0.0	0.0	0.0	457.8
2011	380.8	0.0	77.0	0.0	0.0	0.0	457.8
2012	380.8	0.0	77.0	0.0	120.0	0.0	577.8
2013	380.8	0.0	77.0	0.0	120.0	0.0	577.8
2014	380.8	0.0	77.0	0.0	160.0	0.0	617.8
2015	380.8	0.0	77.0	0.0	40.0	0.0	497.8
2016	380.8	0.0	77.0	0.0	40.0	0.0	497.8
Total	14974.5	9925.0	7653.0	755.0	480.0	50.0	33787.5

Date of Recovery: To be determined once more is known about the biology and population dynamics of the Kauai cluster taxa.

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INTRODUCTION

A. Brief Overview

This recovery plan covers 37 plant taxa that were added to the federal list of endangered and threatened species in six separate listing actions. *Brighamia insignis* (olulu), *Cyanea asarifolia* (haha), *Delissea rhytidosperma* (oha), *Diellia pallida* (no common name (NCN)), *Exocarpos luteolus* (heau), *Hedyotis cookiana* (awiwi), *Hibiscus clayi* (kokio ulaula), *Lipochaeta fauriei* (nehe), *Lipochaeta micrantha* var. *exigua* (nehe), *Lipochaeta micrantha* var. *micrantha* (nehe), *Lipochaeta waimeaensis* (nehe), *Lysimachia filifolia* (NCN), *Melicope haupuensis* (alani), *Melicope knudsenii* (alani), *Melicope pallida* (alani), *Melicope quadrangularis* (alani), *Munroidendron racemosum* (NCN), *Nothocestrum peltatum* (aiea), *Phyllostegia waimeae* (NCN), *Pteralyxia kauaiensis* (kaulu), *Schiedea spergulina* var. *leiopoda* (NCN), and *Solanum sandwicense* (popolo aiakeakua) were listed as endangered, and *Cyrtandra limahuliensis* (haiwale), *Peucedanum sandwicense* (makou), and *Schiedea spergulina* var. *spergulina* (NCN) were listed as threatened on February 25, 1994 (U.S. Fish and Wildlife Service (USFWS) 1994a). *Hedyotis st.-johnii* (NCN) and *Schiedea apokremnos* (NCN) were listed as endangered on September 30, 1991 (USFWS 1991a). *Chamaesyce halemanui* (akoko), *Dubautia latifolia* (naenae), *Poa sandvicensis* (NCN), *Poa siphonoglossa* (NCN), *Stenogyne campanulata* (NCN) and *Xylosma crenatum* (maua) were listed as endangered on May 13, 1992 (USFWS 1992a). *Remya kauaiensis* (NCN) and *Remya montgomeryi* (NCN) were listed as endangered on January 14, 1991 (USFWS 1991b). *Wilkesia hobdyi* (dwarf iliau) was listed as endangered on June 22, 1992, (USFWS 1992b) and *Poa mannii* (Mann's bluegrass) was listed as endangered on November 10, 1994 (USFWS 1994b).

These taxa (hereafter referred to as the Kauai cluster taxa) are scattered throughout Kauai in diverse ecosystems. All but seven of the taxa are or were endemic to the island of Kauai, Hawaiian Islands. The following taxa have historic and/or current populations on other islands as well as Kauai: *Brighamia insignis* on Niihau; *Hedyotis cookiana* on Hawaii (extinct), Molokai (extinct) and Oahu (extinct); *Lysimachia filifolia* on Oahu; *Melicope knudsenii* on Maui; *Melicope pallida* on Oahu (extinct); *Peucedanum sandwicense* on Maui, Molokai and Oahu; and *Solanum sandwicense* on Oahu.

The 37 plant taxa and their habitats have been threatened, or are currently threatened, by one or more of the following: habitat alteration from agriculture, ranching and/or development; trampling, predation and habitat degradation by introduced ungulates (goats (*Capra hircus*), pigs (*Sus scrofa*), axis deer (*Axis axis*), mule deer (*Odocoileus hemionus columbianus*), and cattle (*Bos taurus*)); habitat degradation and competition for space, light, water, and nutrients by naturalized, alien vegetation; fire; introduced birds; predation by rats (*Rattus rattus, Rattus norvegicus* and *Rattus exulans*), mice (*Mus domesticus*) and slugs (*Milax gagates* and other taxa); illegal collecting and other human impacts; insects and disease; and loss of pollinators. Due to the small number of existing individuals and their very narrow distributions, these taxa and most of their populations are subject to an increased likelihood of extinction and/or reduced reproductive vigor from stochastic events (USFWS 1994a).

The land that supports these 37 plant taxa is owned by various private parties, the City and County of Honolulu, and the State of Hawaii, including land classified as State Parks, State Forest Reserves, Natural Area Reserve System (NARS), State Seabird Sanctuaries, and land managed under a cooperative agreement with the National Park Service (USFWS 1994a).

The objective of this plan is to provide a framework for the recovery of these 37 taxa so that their protection by the Endangered Species Act (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.

Part I of this plan has been constructed in a species-by-species format with all the information about a particular species in one section. This format allows for efficient revision to include other Kauai taxa as they are listed. Eventually this will produce one large, coordinated master plan for recovery of plant taxa on the island of Kauai, including a comprehensive analysis of the threats to Kauai ecosystems and species-by-species analyses of recovery actions that are needed for stabilization and recovery. Species can then be grouped within ecosystem types, and projects can be developed that will benefit multiple species with a single recovery action.

B. General Description of Habitat

Information in this section was taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a), although some portions have been slightly modified to include the other taxa covered by this plan.

The plant taxa addressed in this plan are all endemic to the eight "main Hawaiian Islands" (Figure 1), which include: Niihau, Kauai, Oahu, Maui, Molokai, Lanai, Kahoolawe and Hawaii (also known as "the Big Island"). The Hawaiian Islands are located over 3200 kilometers (2000 miles) from the nearest continent, making them the most isolated high islands on earth (Wagner et al. 1990). This isolation has allowed the few plants and animals that arrived here to evolve into many varied and highly endemic species which, in many cases, have lost their defenses against threats

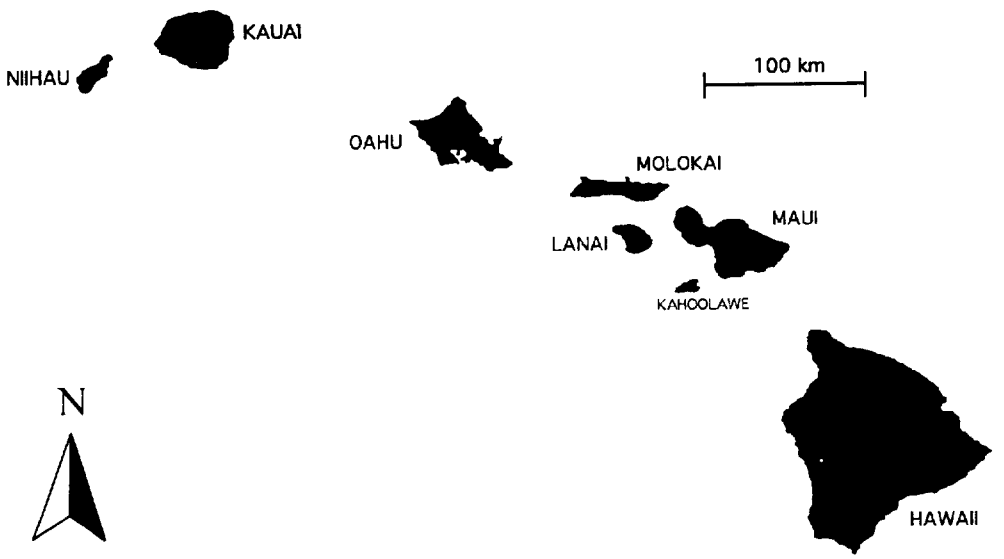

Figure 1. Map of the main Hawaiian islands.

such as mammalian predators and ability to compete with aggressive, alien plant species.

The island of Kauai is the northernmost and oldest of the eight main Hawaiian Islands (Foote et al. 1972). This highly eroded island, characterized by deeply dissected canyons and steep ridges, is 1,430 square kilometers (553 square miles) in area (Department of Geography 1983). Kauai was formed about six million years ago by a single shield volcano. Its caldera, once the largest in the Hawaiian Islands, now extends about 16 kilometers (10 miles) in diameter and comprises the extremely wet, elevated tableland of Alakai Swamp (Department of Geography 1983). Because the highest point on Kauai, at Kawaikini Peak, is only 1,598 meters (5,243 feet) in elevation (Department of Geography 1983), it lacks the contrasting leeward montane rainfall patterns found on other islands which have higher mountain systems. Rainfall is therefore distributed throughout the upper elevations, especially at Mount Waialeale, Kauai's second highest point, at 1,569 meters in elevation (5,148 feet) (Department of Geography 1983), and one of the wettest spots on earth, where annual rainfall averages 1,140 centimeters (450 inches) (Honda et al. 1967, Joesting 1984). To the west of the Alakai Swamp is the deeply dissected Waimea Canyon, extending 16 kilometers (10 miles) in length and up to 1.6 kilometers (1 mile) in width. Later volcanic activity on the southeastern flank of the volcano formed the smaller Haupu caldera. Subsequent erosion and collapse of its flank formed Haupu Ridge (Macdonald et al. 1983). One of the island's most famous features is the Na Pali Coast, where stream and wave action have cut deep valleys and eroded the northern coast to form precipitous cliffs as high as 910 meters (3,000 feet) (Joesting 1984).

Because of its age and relative isolation, levels of floristic diversity and endemism are higher on Kauai than on any other island in the Hawaiian archipelago. However, the vegetation of Kauai has undergone extreme alterations because of past and

present land use. Land with rich soils was altered by the early Hawaiians, and, more recently, converted to agricultural use or pasture (Gagne and Cuddihy 1990). Intentional or inadvertent introduction of alien plant and animal taxa has also contributed to the reduction of native vegetation on the island of Kauai. This problem has been enhanced by the effects of recent hurricanes, which have blown over large areas of native forest, leaving open areas where alien plants are able to establish themselves before the native plants are able to re-grow, and opening paths for further invasion of alien animals. Native forests are now largely limited to the upper elevation mesic and wet regions within Kauai's conservation district between 120 and 1,200 meters (400 and 4,000 feet) in elevation. Most of these forests occur within the western and northwestern portions of the island, where there are two State NARs, two State Forest Reserves, and two State Parks. Most of the taxa included in this plan persist on steep slopes, precipitous cliffs, valley headwalls, and other regions where unsuitable topography has prevented agricultural development or where inaccessibility has limited encroachment by alien animal and plant taxa.

The taxa included in this plan grow in a variety of vegetation communities (grassland, shrubland, and forest), elevational zones (coastal to montane), and moisture regimes (dry to wet). Table 1 summarizes the habitat types in which the Kauai cluster taxa are found. A detailed habitat description for each taxon can be found under the individual species accounts. Appendix D lists some of the associated native species (including threatened, endangered, proposed and candidate taxa) and associated alien species. Appendix E contains a summary of landownership/management of the Kauai cluster taxa.

Table 1. Summary of Kauai cluster taxa habitat types

Taxon	lowland* dry* grassland	lowland dry forest	lowland mesic* forest	montane* mesic forest	lowland wet* forest	montane wet forest	coastal* shrub/ forest
Brighamia insignis	x						
Chamaesyce halemanui				x			
Cyanea asarifolia					x		
Cyrtandra limahuliensis					x		
Delissea rhytidosperma		x	x				
Diellia pallida			x				
Dubautia latifolia			x	x			
Exocarpos luteolus					x	x	
Hedyotis cookiana					x		
Hedyotis st.-johnii							x
Hibiscus clayi		x					
Lipochaeta fauriei			x				
Lipochaeta micrantha var. *exigua*	x		x				
Lipochaeta micrantha var. *micrantha*	x		x				
Lipochaeta waimeaensis			x				
Lysimachia filifolia					x		
Melicope haupuensis			x				
Melicope knudsenii		x	x				
Melicope pallida			x				
Melicope quadrangularis			x		x		
Munroidendron racemosum			x				x
Nothocestrum peltatum				x			
Peucedanum sandwicense			x				x
Phyllostegia waimeae				x		x	
Poa mannii			x	x			

Table 1 (Continued)

Taxon	lowland dry grassland	lowland dry forest	lowland mesic forest	montane mesic forest	lowland wet forest	montane wet forest	coastal shrub/ forest
Poa sandvicensis				x		x	
Poa siphonoglossa				x			
Pteralyxia kauaiensis			x		x		
Remya kauaiensis			x				
Remya montgomeryi			x				
Schiedea apokremnos							x
Schiedea spergulina var. *leiopoda*			x				
Schiedea spergulina var. *spergulina*			x				
Solanum sandwicense			x	x	x		
Stenogyne campanulata				x			
Wilkesia hobdyi		x					
Xylosma crenatum				x			

* coastal = 0-300 meters, lowland = 15-2,000 meters, montane = 500-2,700 meters, dry = <1,200 millimeters annual rainfall, mesic = 1,200-2,500 millimeters annual rainfall, and wet = >2,500 millimeters annual rainfall (Wagner et al. 1990).

C. Overall Reasons for Decline and Current Threats

This section contains a general discussion of threats to the native communities upon which the Kauai cluster taxa depend. Information was taken directly from the listing package covering 24 taxa (USFWS 1994a), although some portions have been slightly modified to include other taxa covered by this plan. Threats specific to each taxon are summarized in Table 2.

The habitats of the plants included in this plan have undergone extreme alteration because of past and present land use practices, including accidental and deliberate alien animal and plant introductions, agricultural development, and recreational use. Natural disturbances such as hurricanes and landslides also destroy habitat and can have a significant effect on small populations of plants. Destruction and modification of habitat by introduced animals and competition with alien plants are the primary threats facing the Kauai cluster taxa.

When Polynesian immigrants settled in the Hawaiian Islands, they brought with them water-control and slash-and-burn systems of agriculture and encouraged plants which they introduced to grow in valleys. Their use of the land resulted in erosion, changes in the composition of native communities, and a reduction of biodiversity (Cuddihy and Stone 1990; Hawaii Heritage Program (HHP) 1990a; Kirch 1982; Wagner et al. 1985). Hawaiians settled and altered many areas of Kauai including areas in which some of the taxa in this plan once grew (HHP 1990a, 1990b).

The destruction increased upon the arrival of Europeans in 1792. Many forested slopes were denuded in the mid- 1800s to supply firewood to whaling ships, plantations, and Honolulu residents. Native plants, such as the historic population of *Lipochaeta micrantha* var. *micrantha* in the Koloa District (HHP 1994), were undoubtedly affected by this practice. Also, sandalwood (*Santalum freycinetianum*) and tree fern (*Cibotium* spp.) harvesting occurred in many areas, changing forest composition and affecting native taxa (Cuddihy and Stone 1990).

Table 2. Summary of threats to the Kauai cluster taxa

Species	Alien Species	Fire	Natural Disasters	Human Impacts
Brighamia insignis	G,I,Pl		X	X
Chamaesyce halemanui	P,Pl		X	X
Cyanea asarifolia	(P,R)		X	X
Cyrtandra limahuliensis	P,Pl		(X)	(X)
Delissea rhytidosperma	D,G,P,R,Pl	X	X	X
Diellia pallida	D,G,P,Pl		X	X
Dubautia latifolia	D,P,Pl		X	X
Exocarpos luteolus	G,P,R,Pl	X	X	(X)
Hedyotis cookiana	(G,P,Pl)		(X)	(X)
Hedyotis st.-johnii	G,Pl			(X)
Hibiscus clayi	(P),Pl			X
Lipochaeta fauriei	G,(P),Pl	X		(X)
L. micrantha var. exigua	P,Pl			(X)
L. " var. micrantha	G,P,Pl			(X)
Lipochaeta waimeaensis	G,Pl		X	X
Lysimachia filifolia	(P), Pl		X	(X)
Melicope haupuensis	G,(I), Pl			X
Melicope knudsenii	C,(D),G,P, I,Pl	(X)		(X)
Melicope pallida	G,P,(I),Pl	X		(X)
M. quadrangularis	(I,Pl)			(X)
Munroidendron racemosum	G,(R,I),Pl	X	X	(X)
Nothocestrum peltatum	D,G,P,J,Pl	X		X
Peucedanum sandwicense	(D),G,Pl	X	X	X
Phyllostegia waimeae	G,Pl		X	X
Poa mannii	G,Pl	X	X	(X)
Poa sandvicensis	P,G,Pl	(X)		X
Poa siphonoglossa	D,P,Pl		X	(X)
Pteralyxia kauaiensis	G,P,(R),Pl	X		(X)
Remya kauaiensis	G,P	(X)	X	(X)
Remya montgomeryi	G,P	(X)	X	(X)
Schiedea apokremnos	G,Pl	X	X	(X)
Schiedea spergulina var. leiopoda	G,Pl		X	(X)
Schiedea spergulina var. spergulina	G,Pl			(X)
Solanum sandwicense	P,Pl	X	X	X
Stenogyne campanulata	G,P,Pl	(X)	X	(X)
Wilkesia hobdyi	G,(Pl)		X	(X)
Xylosma crenatum	(P),Pl		X	X

Key: D - deer, G - goats, P - pigs, R - rats, I - insects, J - red jungle fowl, Pl - plants, () - potential threat.

1. Agriculture/Ranching Operations

Beginning with Captain James Cook in 1792, early European explorers introduced livestock which became feral, increased in numbers and range, and caused significant damage to native communities. In 1848, King Kamehameha III established a provision for land sales to individuals that allowed large-scale agricultural and ranching ventures to begin. So much land was cleared for these enterprises that climatic conditions began to change, and the amount and distribution of rainfall were altered (Wenkam 1969). Plantation owners supported reforestation programs which resulted in many alien trees being introduced in the hope that the watershed could be conserved. Beginning in the 1920s, water collection and diversion systems were constructed in upland areas to irrigate lowland fields, and this undoubtedly destroyed individuals and populations of native plants. Some of the taxa, such as a Kokee population of *Exocarpos luteolus* and Waimea Canyon populations of *Schiedea spergulina* var. *spergulina* and *Xylosma crenatum*, which now occur near ditches of the irrigation system, may have been affected (HHP 1994). The irrigation system also opened new routes for the invasion of alien plants and animals into native forests (Cuddihy and Stone 1990, Culliney 1988, Wagner et al. 1990, Wenkam 1969).

2. Introduced Ungulates

Past and present activities of introduced alien ungulates are the primary factors in altering and degrading vegetation and habitats on all of the main Hawaiian Islands. Feral and domestic ungulates such as goats, pigs, axis deer, mule deer and cattle trample and eat native vegetation and disturb and open new areas. This causes erosion and allows the entry of alien plants (Cuddihy and Stone 1990, Wagner et al. 1990). The majority of the taxa in this plan are directly threatened by habitat degradation resulting from introduced ungulates. Appendix F contains detailed

descriptions of the ungulates that affect the Kauai cluster taxa. Ungulate threats specific to each taxon are discussed in the individual species accounts.

3. Competition from Alien Plant Species

One or more of almost 50 taxa of introduced plants threaten or potentially threaten all of the Kauai cluster plants. The original native flora of Hawaii consisted of about 1,000 taxa, 89% of which were endemic. The current total native and naturalized Hawaiian flora consists of 1,817 taxa. Of this number, 47% were introduced from other parts of the world and nearly 100 taxa have become pests (Smith 1985, Wagner et al. 1990). Naturalized, introduced taxa compete with native plants for space, light, water, and nutrients (Cuddihy and Stone, 1990). Some of these taxa were brought to Hawaii by various groups of people, including the Polynesian immigrants, for food or cultural reasons. Plantation owners, alarmed at the reduction of water resources for their crops caused by the destruction of native forest cover by grazing feral and domestic animals, supported the introduction of alien tree taxa for reforestation. Ranchers intentionally introduced pasture grasses and other taxa for agriculture, and sometimes inadvertently introduced weed seeds as well. Other plants were brought to Hawaii for their potential horticultural value (Cuddihy and Stone 1990, Scott et al. 1986, Wenkam 1969). Appendix F contains a detailed description of the major alien weed threats. Alien weed threats specific to each taxon are discussed in the individual species accounts.

4. Fire

Because Hawaiian plants were subjected to fire during their evolution only in areas of volcanic activity and from occasional lightning strikes, they are not adapted to recurring fire regimes and are unable to recover well following a fire. Alien plants are

often better adapted to fire than native plant taxa, and some fire-adapted grasses have become widespread in Hawaii. The presence of such taxa in Hawaiian ecosystems greatly increases the intensity, extent, and frequency of fire. Fire-adapted alien taxa can reestablish in a burned area, resulting in a reduction in the amount of native vegetation after each fire. Fire is a serious, immediate threat along the Na Pali coast, especially during drier months. The most prominent threat is fires caused by people pursuing recreational activities, and prevailing winds spreading fires to inland areas. Fire could destroy seeds as well as plants, even on steep cliffs (Clarke and Cuddihy 1980, Corn et al. 1979, Cuddihy and Stone 1990). Fire is a threat to *Brighamia insignis*, *Delissea rhytidosperma*, *Exocarpos luteolus*, *Hedyotis st.-johnii*, *Lipochaeta fauriei*, *Lipochaeta waimeaensis*, *Melicope knudsenii*, *Melicope pallida*, *Munroidendron racemosum*, *Nothocestrum peltatum*, *Peucedanum sandwicense*, *Poa mannii*, *Pteralyxia kauaiensis*, *Remya kauaiensis*, *Schiedea apokremnos*, and *Solanum sandwicense* (Bruegmann 1990, Cuddihy and Stone 1990, HHP 1994, National Tropical Botanical Garden (NTBG) 1994, Medeiros et al. 1986, St. John 1981).

5. Introduced Birds

The red jungle-fowl, an introduced ground-nesting bird, potentially threatens the Makaha Valley, Kauai, population of *Nothocestrum peltatum*. Red jungle fowl were introduced to Hawaii by the Polynesian immigrants and became feral in the forests. Red jungle fowl disturb the ground cover while foraging, thus disrupting seedling establishment (Cuddihy and Stone 1990, NTBG 1994, Scott et al. 1986).

Other introduced birds may have contributed to the decline of, and/or may currently threaten, some or all of the Kauai cluster taxa through their spread of alien plant seeds, and through their role as competitors and disease vectors for native pollinating birds.

6. Predation

Of the four species of rodents which have been introduced to the Hawaiian Islands, the species with the greatest impact on the native flora and fauna is probably the black or roof rat, which now occurs on all the main Hawaiian Islands around human habitations, in cultivated fields, and in dry to wet forests. Black rats, and to a lesser extent house mice, Polynesian rats, and Norway rats, eat the fruits of some native plants, especially those with large, fleshy fruits. Many native Hawaiian plants produce their fruit over an extended period of time, and this produces a prolonged food supply which supports rodent populations. Black rats strip bark from some native plants (Cuddihy and Stone 1990, Tomich 1986). Rats threaten *Delissea rhytidosperma* by damaging the fruits and stems (Bruegmann 1990), and eat the fruits of *Exocarpos luteolus*. It is probable that rats damage the fruit and stems of *Cyanea asarifolia*, *Munroidendron racemosum* and *Pteralyxia kauaiensis*, which have fleshy fruits and populations in areas where rats occur (Lamoureux 1982).

Common garden slugs have become widespread in Hawaii and may pose a major, but little-recognized threat to native plant species. Slugs can damage flowers, fruits, stems and seedlings of native plants. Slug damage has been documented on *Cyanea asarifolia* and slugs are a potential threat to other Kauai cluster taxa (USFWS 1994a).

7. Illegal Collecting and Other Human Impacts

Illicit cultivation of *Cannabis sativa* (marijuana) occurs in isolated portions of public and private lands in the Hawaiian Islands. This agricultural practice opens areas in native forest into which alien plants invade after the patches are abandoned (HHP 1990c). Marijuana cultivation is considered a management problem in Hono O Na Pali and Kuia NAR and is a potential threat

to the following taxa, which have populations in those areas: *Brighamia insignis*, *Chamaesyce halemanui*, *Delissea rhytidosperma*, *Dubautia latifolia*, *Munroidendron racemosum*, *Peucedanum sandwicense*, *Pteralyxia kauaiensis*, and *Solanum sandwicense* (HHP 1994).

Unrestricted collecting for scientific or horticultural purposes and excessive visits by individuals interested in seeing rare plants could result from increased publicity. This is a potential threat to all the taxa, but especially to *Cyanea asarifolia*, *Delissea rhytidosperma*, *Diellia pallida*, *Hibiscus clayi*, *Lipochaeta waimeaensis*, *Melicope haupuensis*, *Phyllostegia waimeae*, *Remya montgomeryi* and *Stenogyne campanulata*, each of which has only 1 or 2 populations and a total of 10 or fewer individuals. Collection of whole plants or reproductive parts of any of these seven taxa could cause an adverse impact on the gene pool and threaten the survival of the taxa. Some taxa, such as *Brighamia insignis*, *Exocarpos luteolus*, *Hibiscus clayi*, *Nothocestrum peltatum*, *Peucedanum sandwicense*, and *Solanum sandwicense*, have populations close to trails or roads and are thus easily accessible to collectors (HHP 1994).

Many of the plants occur in recreational areas used for hiking, camping, and hunting. Tourism is a growing industry in Hawaii, and as more people seek recreational activities, they are more likely to come into contact with rare native plants. People threaten rare plants by introducing alien plants through seeds on their footwear, causing erosion, trampling plants, and starting fires (Corn et al. 1979). *Brighamia insignis*, *Chamaesyce halemanui*, *Dubautia latifolia*, *Hibiscus clayi*, *Peucedanum sandwicense*, *Poa sandvicensis* and *Poa siphonoglossa* have populations next to trails and are considered to be immediately threatened by recreational use of the areas in which they occur (Clarke and Cuddihy 1980, Takeuchi 1982).

Vehicle traffic and road maintenance constitute a potential threat to several *Dubautia latifolia* individuals that overhang a state park road. Road maintenance was responsible for the

destruction of a *Xylosma crenatum* individual, and is a continuing threat to all taxa which occur next to roads and/or trails.

8. Insects and Disease

The black twig borer (*Xylosandrus compactus*) is a small, introduced beetle about 1.6 millimeters (0.06 inches) in length which burrows into branches, introduces a pathogenic fungus as food for its larvae, and lays its eggs. Twigs, branches, and even the entire plant can be killed from such an infestation. In the Hawaiian Islands, the black twig borer has many hosts, disperses easily, and is probably present at most elevations up to 670 meters (2,500 feet). It is known to attack *Melicope* spp. and is a potential threat to *Melicope haupuensis*, *M. knudsenii*, *M. pallida*, and *M. quadrangularis*, all of which grow in areas where the insect is believed to be present (Davis 1970, Hara and Beardsley 1979, Hill 1987, Medeiros et al. 1986, Samuelson 1981).

Carmine spider mite (*Tetranychus cinnabarinus*), another introduced insect, has been observed to cause leaf loss in both cultivated and wild individuals of *Brighamia insignis* and an introduced insect of the longhorned beetle family (Cerambycidae) that killed a mature, cultivated *Munroidendron racemosum* individual has the potential of affecting wild trees (HHP 1994).

Sophonia rufofascia (two-spotted leafhopper) is a potential threat to the Kauai cluster taxa and the surrounding ecosystems. It was introduced to Hawaii in the late 1980's and has been found on all of the major Hawaiian Islands. The two-spotted leafhopper injects toxins while feeding which causes yellowing and wilting within the feeding area on a plant (Adam Asquith, USFWS, personal communication 1995). Recent observations indicate that this insect is killing plants on the Na Pali Coast and in the Haupu Range (Ken Wood, NTBG, personal communication 1994).

Disease is not known to be a direct threat to any of the Kauai cluster taxa. However, it is a possible factor in the

seasonal blackening and dieback of shoot tips of *Dubautia latifolia* (USFWS 1992a).

9. Loss of Pollinators

Loss of pollinators is a possible threat to many of the Kauai cluster taxa, particularly *Brighamia insignis* (L. Mehrhoff, personal communication 1994). Many native birds and insects which may have acted as pollinators have become extinct or declined drastically from historic levels. Research to determine the presence/absence and nature of appropriate pollinators for each of the Kauai cluster taxa will be essential to their recovery.

10. Small Number of Populations and Individual Plants

The small number of populations and individual plants of all of these taxa increases the potential for extinction from stochastic events. The limited gene pool may depress reproductive vigor, or a single man-caused or natural environmental disturbance could destroy a significant percentage of the individuals (or the only known extant population) of these taxa.

Erosion, landslides, and rock slides due to natural weathering can result in the death of individual plants as well as habitat destruction. This especially affects the continued existence of taxa with limited numbers and/or narrow ranges, such as *Cyanea asarifolia*, *Delissea rhytidosperma*, *Lysimachia filifolia*, *Poa mannii*, *Schiedea spergulina* var. *leiopoda*, and *Solanum sandwicense* (CPC 1990a, HHP 1994, NTBG 1994, Lorence and Flynn 1991). Individuals of other species, such as *Hedyotis cookiana*, *Hedyotis st.-johnii*, *Cyrtandra limahuliensis* and *Schiedea apokremnos* are potentially threatened by substrate loss. This process is often exacerbated by human disturbance and land use practices.

In November 1982, Hurricane Iwa struck the Hawaiian Islands and caused extensive damage, especially on the island of Kauai.

Many forest trees were destroyed, opening the canopy and thus allowing the invasion of light-loving alien plants, which are a threat to the continued existence of many of the taxa. Hurricane Iniki hit the island of Kauai in September 1992, and caused significant damage to rare plant populations on that island. Populations of at least four taxa in this plan were seriously damaged by this hurricane: *Cyanea asarifolia*, *Brighamia insignis*, *Lysimachia filifolia*, and *Delissea rhytidosperma*. Damage by additional hurricanes could further decrease the already reduced habitat of the Kauai cluster taxa.

D. Overall Conservation Efforts

1. Federal Actions

Two of the taxa included in this plan were listed as endangered on January 14, 1991 (USFWS 1991b), two were listed as endangered on September 30, 1991 (USFWS 1991a), six were listed as endangered on May 13, 1992 (USFWS 1992a), one was listed as endangered on June 22, 1992 (USFWS 1992b), twenty-two (22) were listed as endangered and three were listed as threatened on February 25, 1994 (USFWS 1994a), and one was listed as endangered on November 10, 1994 (USFWS 1994b).

The Federal listing of the taxa in the Kauai cluster as endangered or threatened has afforded each the protection of the ESA. When a species is listed as endangered or threatened under the ESA, it is automatically added to the State of Hawaii's list of protected species (Hawaii Revised Statutes Chapter [HRS] 195D). Hawaii State law prohibits taking of endangered flora and encourages conservation by State government agencies. ("Take" as defined by Hawaii State law means "to harass, harm..., wound, kill..., or collect endangered or threatened... species... or to cut, collect, uproot, destroy, injure, or possess endangered or threatened... species of... land plants, or to attempt to engage in any such conduct" [HRS 195D].) The ESA offers additional

Federal protection to these taxa since it is a violation of the ESA for any person to remove, cut, dig up, 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 Kauai 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 1991a, 1991b, 1992a, 1992b, 1993, 1994a and 1994b).

2. State Actions

The majority of habitat for the Kauai cluster plants occurs on lands owned and managed by the State of Hawaii. All of this land is under protective status in the form of State Parks, NARs, Wilderness Preserves and Forest Reserves. However, ungulate populations are deliberately maintained for hunting in several of these areas.

Kauai District Division of Forestry and Wildlife (DOFAW) has done outplanting and protective fencing for many of the Kauai cluster taxa. About 20 *Brighamia insignis*, 11 *Hibiscus clayi*, 400 *Munroidendron racemosum*, 20 *Wilkesia hobdyi* and 9 *Cyanea asarifolia* have been outplanted, and outplanting is planned for *Xylosma crenatum*. Fencing was recently completed in Kuia NAR, which protects populations of *Solanum sandwicense* and *Xylosma crenatum*. A plant sanctuary project which will include fencing and other management for *Exocarpos luteolus, Melicope pallida, Poa mannii, Poa siphonoglossa* and *Remya montgomeryi* is planned for the Kalalau Rim area. There are plans to use this sanctuary for research as well as educational purposes. Fencing projects are also being planned to protect the Makaha Ridge *Chamaesyce*

halemanui population and an un-named *Melicope* species which also occurs there, and to protect about 15 *Remya kauaiensis* in Kokee State Park (Galen Kawakami, Kauai DOFAW, personal communication 1994).

3. Nongovernmental Actions

Seeds and/or plants of some of these taxa have been collected by NTBG, located on the island of Kauai, Hawaii. Many of these have also been successfully propagated in their facilities. Waimea Arboretum and Lyon Arboretum have also successfully propagated some of the Kauai cluster taxa. Tables 3, 4 and 5 present current holdings at Waimea Arboretum, Lyon Arboretum and NTBG. NTBG's plans for these holdings include research into propagation methods and feasibility of long-term seed storage (D. Ragone, personal communication 1994). Although seeds of many Kauai cluster taxa are in short-term storage at these facilities, traditional methods of seed storage have generally not been successful for long-term storage, and additional research into long-term seed storage is needed (Marie Bruegmann, USFWS, personal communication 1995).

Taxon	# of Plants
Brighamia insignis	14
Delissea rhytidosperma	19 and 100 seedlings
Hibiscus clayi	21 (2 obtained as plants)
Lipochaeta micrantha var. micrantha	26 and 10 cuttings
Munroidendron racemosum	3
Peucedanum sandwicense	24
Solanum sandwicense	2 (both obtained as plants)

Table 3. Plants of the Kauai cluster taxa propagated at Waimea Arboretum, Oahu (Josephine Llop, Waimea Arboretum, personal communication 1995)

Taxon	Tissue Culture	Greenhouses and Nursery	Arboretum Grounds
Brighamia insignis	2	28	
Cyanea asarifolia	1283	3	
Delissea rhytidosperma	93	1	
Exocarpos luteolus	seed		
Hibiscus clayi		2	22
Lipochaeta micrantha var. micrantha		36	
Lipochaeta waimeaensis			28
Lysimachia filifolia		5	
Munroidendron racemosum	seed		5
Solanum sandwicense	12		
Xylosma crenatum	seed		

Table 4. Plants of the Kauai cluster taxa propagated at Lyon Arboretum as of December 1994 (Dr. Charles Lamoureux, Lyon Arboretum, personal communication 1995)

Taxon	Seeds in Storage	Successfully Propagated	Successfully Grown Ex Situ
Brighamia insignis	276	Y	X*
Chamaesyce halemanui	0	Y	
Cyanea asarifolia	1700	Y	X
Cyrtandra limahuliensis	550+	Y	
Delissea rhytidosperma	2000+	Y	X*
Diellia pallida	0	N	
Dubautia latifolia	20,000	Y	
Exocarpos luteolus	13	Y	
Hedyotis cookiana	2	Y	X
Hedyotis st.-johnii	5000+	Y	X
Hibiscus clayi	2	Y	X*
Lipochaeta fauriei	0	Y	X*
Lipochaeta micrantha var. exigua	0	Y	X*
Lipochaeta micrantha var. micrantha	0	Y	X*
Lipochaeta waimeaensis	430	Y	
Lysimachia filifolia	300	Y	
Melicope haupuensis	0	N	
Melicope knudsenii	0	N	
Melicope pallida	89	N	
Melicope quadrangularis	0	N	
Munroidendron racemosum	830	Y	X*
Nothocestrum peltatum	125+	Y	
Peucedanum sandwicense	2100+	Y	
Phyllostegia waimeae	0	N	
Poa mannii	1220	N	
Poa sandvicensis	460	N	
Poa siphonoglossa	580	N	
Pteralyxia kauaiensis	37	Y	
Remya kauaiensis	100,000+	N	
Remya montgomeryi	30,000+	N	
Schiedea apokremnos	395	Y	X
Schiedea spergulina var. spergulina	500	N	
Schiedea spergulina var. leiopoda	500	N	
Solanum sandwicense	1000+	Y	X*
Stenogyne campanulata	14	Y	X*
Wilkesia hobdyi	12,000	Y	X*
Xylosma crenatum	35	Y	X*

Table 5. Seeds and plants of the Kauai cluster taxa at the NTBG, Kauai (D. Ragone, personal communication 1995).

* Plants presently growing at garden

E. Overall Recovery Strategy

The plan for recovery is detailed in the step-down narrative in Part II. The plan begins with the protection and management of current habitats of the Kauai cluster taxa. Current threats are addressed through fencing and/or hunting to control ungulates; control of alien plants; protection from fire; control of rodents and slugs; control of insects pests 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 study the growth and reproductive viability of each taxon, determine the parameters of viable populations of each taxon, study the reproductive strategy and pollinators of each taxon, study possible pests and diseases, and use the results of such research to improve management practices.

A program of augmentation of very small populations and re-establishment of new populations within the historical range of the species is also needed. This 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.

A public education program is also needed to increase public awareness and support for plant recovery efforts.

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

F. Species Accounts

1. ***Brighamia insignis*** - Recovery Priority # (RP#) - 5 (See Appendix G for a description of the Recovery Priority System).

a. Description and Taxonomy

Appendix B contains a line drawing of *Brighamia insignis*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Asa Gray (in Mann 1868) described *Brighamia insignis* based upon alcohol-preserved flowers and fruits collected by William Tufts Brigham on Molokai and a dried specimen collected on Kauai or Niihau by Ezechiel Jules Remy. The specific epithet means "outstanding," referring to the plant's unique appearance. Brigham's bottled material, since lost, would today be considered to be *Brighamia rockii*. Other published names that Thomas G. Lammers (1989), in the currently accepted treatment of the genus, considers to be synonymous with *B. insignis* include *B. insignis* f. *citrina* (Forbes 1917a), *B. citrina* (St. John 1958), and *B. citrina* var. *napaliensis* (St. John 1969b).

Brighamia insignis, a member of the bellflower family (Campanulaceae), is an unbranched plant 1 to 5 meters (3 to 16 feet) tall with a succulent stem that is bulbous at the bottom and tapers toward the top. The fleshy leaves, which measure 12 to 20 centimeters (5 to 8 inches) long and 6.5 to 11 centimeters (2.5 to 4.5 inches) wide, are arranged in a compact rosette at the apex of the stem. Fragrant yellow flowers are clustered in groups of three to eight in the leaf axils (the point between the leaf and the stem), with each flower on a stalk 1 to 3 centimeters (0.4 to 1.2 inches) long. The hypanthium (basal portion of the flower) has 10 ribs and is topped with 5 oval or loosely triangular calyx lobes (partially fused sepals) 0.5 to 1 millimeters (0.02 to 0.04

inches) long. The yellow petals are fused into a tube 7 to 14 centimeters (2.8 to 5.5 inches) long and 3 to 4 millimeters (0.1 to 0.2 inches) wide, which flares into five elliptic lobes. The fruit is a capsule 13 to 19 millimeters (0.5 to 0.7 inches) long which contains numerous seeds. This species is a member of a unique endemic Hawaiian genus with only one other species, presently known only from Molokai, from which it differs by the color of its petals, its shorter calyx lobes, and its longer flower stalks (Hillebrand 1888; Johnson 1986; Lammers 1990; Rock 1919; St. John 1958, 1969b; Takeuchi 1982).

b. Life History

Current reproduction is not thought to be sufficient to sustain populations, with poor seedling establishment due to competition with alien grasses as the limiting factor (Takeuchi 1982, USFWS 1994a). Pollination by sphingid moths is likely (David Lorence, NTBG, personal communication 1994). Pollination failure is common, and may be due to a lack of pollinators or a reduction in genetic variability due to the few remaining individuals. The flower structure appears to favor outcrossing. Some vegetative cloning has been observed and flower and leaf size appear to be dependent on moisture availability (Takeuchi 1982, USFWS 1994a). Seeds of this species are undoubtedly dispersed by gravity. Although they may be blown for short distances, they are not obviously adapted for wind dispersal, being ovoid to ellipsoid, smooth, and lacking any sort of wing or outgrowth (David Lorence, NTBG, personal communication 1994).

c. Habitat Description

Brighamia insignis grows from sea level to 400 meters (1,300 feet) on rocky ledges with little soil or steep sea cliffs in lowland dry grassland and shrubland. This habitat has annual rainfall that is usually less than 170 centimeters (65 inches).

Associated native plant taxa include *Canthium odoratum* (alahee), *Chamaesyce celastroides* (akoko), *Eragrostis variabilis* (kawelu), and *Heteropogon contortus* (pili grass) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Brighamia insignis*.

Historically, *B. insignis* was known from the headland between Hoolulu and Waiahuakua Valleys along the Na Pali Coast on the island of Kauai, and from Kaali Spring on the island of Niihau (HHP 1994). The five extant populations grow on State and private land and total approximately 60 to 70 plants. Two populations are found along the Na Pali Coast, although approximately half of the individuals were destroyed in 1992 by Hurricane Iniki. These populations are within 0.6 kilometers (0.4 miles) of each other within or on the boundary of the Hono O Na Pali NAR (HHP 1994). The most recent observations estimate the population at Hoolulu to be 10 to 20 plants and the population at Waiahuakua to be 30 to 40 plants (Steve Perlman, NTBG, personal communication 1994). There are also two populations in the Haupu Range within 4.3 kilometers (2.7 miles) of each other (HHP 1994). Hurricanes Iwa and Iniki destroyed 10 of the 12 individuals in the Haupu area. Still surviving are one plant at Mt. Haupu and one plant at Niumalu (S. Perlman, personal communication 1994). The status of the small population on privately owned Niihau is not known, although there are reports that it was destroyed when the supporting cliff fell away (HHP 1994, Wichman and St. John 1990, USFWS 1994a).

e. Reasons for Decline and Current Threats

The major threats to *Brighamia insignis* are predation and habitat degradation by feral goats and competition from alien plant species such as *Melinus minutiflora* (molasses grass), *Setaria gracilis* (yellow foxtail), *Sporobolus africanus*

(smutgrass), lantana, *Psidium cattleianum* (strawberry guava), *Psidium guajava* (common guava), *Kalanchoe pinnata* (air plant), *Ageratum conyzoides* (maile hohono) and *Stachytarpheta* (NCN)). Additional threats include human disturbance, fire, and the Carmine spider mite. *Brighamia insignis* is also threatened by stochastic extinction due to the small number of individuals and their restricted distribution. Small numbers may result in reduced reproductive vigor, and stochastic environmental disturbances, such as rock slides, are frequent in their cliff habitat (USFWS 1994a).

f. Conservation Measures

Brighamia insignis has been successfully propagated and grown *ex situ* by Lyon Arboretum, NTBG, and Waimea Arboretum. Present holdings at Lyon Arboretum consist of 2 plants in the tissue culture lab, 10 plants in the greenhouse and 18 plants in the nursery (C. Lamoureux, personal communication 1995). NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995), and Waimea Arboretum has 14 plants (J. Llop, personal communication 1995).

The Kauai District of DOFAW has outplanted 20 individuals of *Brighamia insignis* at Kalepa and Nounou Forest Reserves (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *B. insignis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately. It also crucial to protect the remaining wild individuals from goats and alien weed

threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

2. ***Chamaesyce halemanui*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Chamaesyce halemanui*.

The information in this section is taken directly from the listing package covering six of the Kauai cluster taxa (USFWS 1992a).

C. halemanui was first collected in 1840 on Kauai by the U.S. South Pacific Exploring Expedition (Degener and Degener 1959b). In 1936, Edward Sherff named that specimen *Euphorbia remyi* var. *wilkesii*, and also named specimens from one collection from the Halemanu drainage both *E. halemanui* and *E. remyi* var. *leptopoda* (Koutnik 1987). Otto and Isa Degener and L. Croizat (Degener and Croizat 1936; Degener and Degener 1959a, 1959b) transferred all of those names to the genus *Chamaesyce*. In 1987, Daryl Koutnik reduced the two varieties listed above, and *Euphorbia remyi* var. *molesta* (Sherff 1938), to synonymy under *Chamaesyce halemanui*.

C. halemanui is a scandent (climbing) shrub in the spurge family (Euphorbiaceae) with stems 1 to 4 meters (3 to 13 feet) long. The egg-shaped to inversely lance-shaped leaves are decussate (successive pairs of leaves at right angles to the previous pair). The leaves are 4 to 13 centimeters (1.6 to 5 inches) long and 1 to 4.5 centimeters (0.4 to 1.8 inches) wide, with persistent stipules (small appendages at the base of the petioles (stem of the leaf)). Groups of flowers (cyathia) are in dense, compact, nearly spherical clusters or occasionally solitary in leaf axils. The stems of cyathia are about 2 millimeters (0.08 inches) long, or if solitary, about 5 millimeters (0.2 inches) long. The fruits are green capsules, about 3 millimeters (0.1

inches) long, on recurved stalks, enclosing gray to brown seeds. *Chamaesyce halemanui* is distinguished from closely related species by its decussate leaves, persistent stipules, more compact flower clusters, shorter stems on cyathia, and smaller capsules (Koutnik 1987, Koutnik and Huft 1990).

b. Life History

Little is known about the life history of *C. halemanui*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Chamaesyce halemanui typically grows on the steep slopes of gulches in mesic *Acacia koa* (koa) forests at an elevation of 660 to 1,100 meters (2,160 to 3,600 feet). Associated native species include *Metrosideros polymorpha* (ohia), *Alphitonia ponderosa* (kauila), *Antidesma platyphyllum* (hame), *Coprosma* (pilo), *Diospyros sandwicensis* (lama), *Dodonaea viscosa* (aalii), *Elaeocarpus bifidus* (kalia), *Pisonia* (papala kepau), *Santalum freycinetianum* (iliahi), and *Styphelia tameiameiae* (pukiawe). Associated alien species include *Aleurites moluccana* (kukui), *Lantana camara* (lantana), strawberry guava, *Rubus argutus* (prickly Florida blackberry), and *Stenotaphrum secundatum* (St. Augustine grass) (USFWS 1992a).

d. Historic and Current Range and Population Status

Appendix C contains a map of historic and current range of *Chamaesyce halemanui*.

All collections and confirmed sightings of this species are from seven areas on Kauai: Kauhao and Makaha Valleys in Na Pali-Kona Forest Reserve; Mahanaloa Valley in Kuia NAR; the Halemanu

drainage, near Waipoo Falls and Kokee Ranger Station in Kokee State Park; and Olokele Canyon on privately owned land (HHP 1994). *Chamaesyce halemanui* is now known to be extant at Kohua Ridge (15 individuals), Makaha Valley (50 to 100 individuals), Waialae Ridge (6 individuals), and the Halemanu drainage (25 to 30 individuals), and all currently extant populations are on State-owned land (HHP 1994, USFWS 1992a, S. Perlman, personal communication 1995).

e. Reasons for Decline and Current Threats

The major threats to *Chamaesyce halemanui* are competition from alien plants (St. Augustine grass, lantana, and strawberry guava), and habitat degradation by feral pigs (Makaha population). With such a small population size and restricted distribution, *Chamaesyce halemanui* faces an increased potential for extinction resulting from stochastic events. This species' limited gene pool also constitutes a serious potential threat because of the possibility of depressed reproductive vigor (USFWS 1992a).

f. Conservation Measures

This taxon has been successfully propagated by NTBG, although they do not presently have any seeds in short-term storage (D. Ragone, personal communication 1995). The Kauai District DOFAW is planning a fencing project to protect the Makaha Ridge population of this taxon (G. Kawakami, personal communication 1994). No additional specific conservation measures are being conducted for *Chamaesyce halemanui* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock

ex situ should be undertaken immediately, as well as the protection of remaining wild individuals from feral pigs and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

3. ***Cyanea asarifolia*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Cyanea asarifolia*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Robert W. Hobdy collected a specimen of *Cyanea asarifolia* on Kauai in 1970; Harold St. John (1975) later described and named the taxon. The specific epithet refers to the leaves, which are similar in shape to those in the genus *Asarum*. Recently, St. John (1987d, St. John and Takeuchi 1987) placed the genus *Cyanea* in synonymy with *Delissea*, resulting in the new combination *Delissea asarifolia*, but Lammers (1990) retains both genera in the currently accepted treatment of the family.

Cyanea asarifolia, a member of the bellflower family, is a sparingly branched shrub 0.3 to 1 meters (1 to 3.3 feet) tall. The heart-shaped leaves are 8.5 to 10.5 centimeters (3.3 to 4.1 inches) long and 7 to 8 centimeters (2.8 to 3.1 inches) wide with leaf stalks 12 to 15 centimeters (4.7 to 5.9 inches) long. Thirty to 40 flowers are clustered on a stalk 25 to 30 millimeters (1 to 1.2 inches) long, each having an individual stalk 7 to 10 millimeters (0.3 to 0.4 inches) in length. The slightly curved flowers are white with purple stripes, 20 to 22 millimeters (0.8 to 0.9 inches) long, and about 3.5 millimeters (0.1 inches) wide with spreading lobes. The five anthers have tufts of white hairs at the tips. The nearly spherical fruit is a dark purple berry about 1 centimeter (0.4 inches) long. This species is

distinguished from others of the genus that grow on Kauai by the shape of the leaf base, the leaf width in proportion to the length, and the presence of a leaf stalk (Lammers 1990, St. John 1975).

b. Life History

Little is known about the life history of *Cyanea asarifolia*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species typically grows in pockets of soil on sheer rock cliffs in lowland wet forests at an elevation of approximately 330 meters (1,080 feet). Associated plant taxa include ferns, *Hedyotis elatior* (manono), ohia, *Touchardia latifolia* (olona), and *Urera glabra* (opuhe) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Cyanea asarifolia*.

Robert W. Hobdy first collected a specimen of *Cyanea asarifolia* on Kauai in 1970. For over 20 years, *Cyanea asarifolia* was known only from a population of five or six plants above the bed of Anahola Stream on Kauai at its type locality (HHP 1994). Because recent attempts to locate this population were unsuccessful, this population is now thought to be extirpated (USFWS 1994a). In 1991, Steven Perlman and Ken Marr discovered a population of 14 mature plants and 5 seedlings at the headwaters of the Wailua River in central Kauai on State-owned land (HHP 1994; USFWS 1994a). In 1992, Hurricane Iniki heavily damaged the *Cyanea asarifolia* population, either directly or indirectly

destroying all but four to five juvenile plants (S. Perlman, personal communication 1995).

e. Reasons for Decline and Current Threats

The major threat to *Cyanea asarifolia* is stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals. The single known population is vulnerable to hurricanes, natural rock slides, and over-collecting for scientific purposes. Plants observed after Hurricane Iniki were frequently damaged by introduced slugs or rodents. Habitat degradation by feral pigs is also a potential threat (USFWS 1994a).

f. Conservation Measures

This taxon has been successfully propagated and grown *ex situ* by NTBG, and they presently have seeds in short-term storage (D. Ragone, personal communication 1995). Lyon Arboretum presently has 1,283 plants in the tissue culture lab and three individuals in their certified greenhouse (C. Lamoureux, personal communication 1995). The Kauai District DOFAW has outplanted nine individuals of this taxon in the "blue hole" area of Mount Waialeale (G. Kawakami, personal communication 1995). No additional specific conservation measures are being conducted for *Cyanea asarifolia* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral pigs, slugs

and rodents. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

4. ***Cyrtandra limahuliensis*** - RP# 14

a. Description and Taxonomy

There is no line drawing available for *Cyrtandra limahuliensis*

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Lawrence H. MacDaniels first collected *Cyrtandra limahuliensis* on Kauai in 1926. St. John (1987a) described the species, naming it for Limahuli Valley, where Steven Perlman collected the type specimen in 1978.

Cyrtandra limahuliensis, a member of the African violet family (Gesneriaceae), is an unbranched or few-branched shrub up to 1.5 meters (5 feet) tall. The opposite, elliptic leaves are usually 15 to 30 centimeters (6 to 12 inches) long and 5 to 12 centimeters (2 to 4.7 inches) wide. The upper surface of the toothed leaves is moderately hairy and the lower surface, with deep veins, is moderately or densely covered with yellowish brown hairs. Single downy flowers are borne in the leaf axils. The slightly curved corolla tube (fused petals) barely extends beyond the calyx. The calyx encloses the approximately 2 centimeters (0.8 inches) long berries at maturity. The following combination of characteristics distinguish this species from others of the genus: The leaves are usually hairy, especially on lower surfaces; the usually symmetrical calyx is tubular or funnel-shaped and encloses the fruit at maturity; and the flowers are borne singly (St. John 1987a, Wagner et al. 1990).

b. Life History

Little is known about the life history of *Cyrtandra limahuliensis*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species typically grows along streams in lowland wet forests at elevations between 240 and 870 meters (800 and 2,850 feet). Associated taxa include *Antidesma platyphyllum* var. *hillebrandii* (hame), *Athyrium sandwichianum* (hoio), *Perrottetia sandwicensis* (olomea), ohia, *Dicranopteris linearis* (uluhe), *Gunnera kauaiensis* (apeape), *Hedyotis* sp. (manono), and *Psychotria* sp. (kopiko) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Cyrtandra limahuliensis*.

Historically, *C. limahuliensis* was known from three locations on Kauai: Wainiha and Lumahai Valleys and near Kilauea River (HHP 1994, USFWS 1994a). One population remains in Wainiha Valley and eleven others exist on Kauai: in Limahuli Valley, Waipa Valley, on Mount Kahili, along the north fork of Wahiawa Stream, along Anahola Stream, Waioli Valley, and near Powerline Trail on private and State land (HHP 1994, NTBG 1994, USFWS 1994a, Lorence and Flynn 1991). The 12 known populations, distributed over a 20- by 30-kilometer (13- by 18-mile) area, range in size from solitary shrubs to large populations of over 1,000 plants (HHP 1994, D. Lorence and Flynn 1993). The largest populations of this species occur in the upper Waioli Valley, where three populations total at least 2,100 individuals (Lorence and Flynn 1993). Another location with "hundreds or perhaps thousands" of plants (USFWS

1994a) is limited to a 0.4 square kilometer (0.25 square mile) area along the north fork of the Wailua River. Other botanists familiar with this population believe it to number no more than 500 individuals (USFWS 1994a). There are an estimated total of 10,000 individuals in these 12 populations (S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The major threat to *Cyrtandra limahuliensis* is competition from alien plant species, especially strawberry guava. Each population has additional threats: competition with *Paspalum conjugatum* (Hilo grass) and *Melastoma candidum* (NCN) at the Mount Kahili population; competition with common guava and habitat degradation by feral pigs at the Anahola Stream population; and competition with *Hedychium flavescens* (yellow ginger) at the Wainiha Valley population. Individuals of the Wailua Stream population are situated at the base of a steep cliff and are vulnerable to natural landslides. The Waioli Valley populations are threatened by several alien weeds: *Rubus rosifolius* (thimbleberry), *Youngia japonica* (Oriental hawksbeard), *Erechtites valerianifolia* (fireweed), and *Blechnum occidentale* (NCN). *Clidemia hirta* (Koster's curse) is a potential threat to this taxon. Hurricanes are also a potential threat, although most of the plants have grown back vigorously since Hurricane Iniki (USFWS 1994a).

f. Conservation Measures

This taxon has been successfully propagated by NTBG, and they presently have seeds in short-term storage (D. Ragone, personal communication 1995). No additional specific conservation measures are being conducted for *Cyrtandra limahuliensis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

5. ***Delissea rhytidosperma*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Delissea rhytidosperma*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Remy first collected a specimen of *Delissea rhytidosperma* on Kauai between 1851 and 1855. Horace Mann, Jr. (1867) chose the specific epithet to describe its wrinkled seeds. Heinrich Wawra (1873) later described another species, *D. kealiae*, which he said was closely related to *D. rhytidosperma*. In the current treatment of the family, Lammers (1990) considers *D. kealiae* to be synonymous with *D. rhytidosperma*.

Delissea rhytidosperma, a member of the bellflower family, is a branched shrub 0.5 to 2.5 meters (1.6 to 8.2 feet) tall. The lance-shaped or elliptic leaves are 8 to 19 centimeters (3.1 to 7.5 inches) long and 2 to 5.5 centimeters (0.8 to 2.2 inches) wide and have toothed margins. Clusters of 5 to 12 flowers are borne on stalks 1 to 2 centimeters (0.4 to 0.8 inches) long; each flower has a stalk 8 to 13 millimeters (0.3 to 0.5 inches) long. The greenish white (sometimes pale purple) corolla is 14 to 20 millimeters (0.6 to 0.8 inches) long. The stamens are hairless, except for a small patch of hair at the base of the anthers. The nearly spherical dark purple fruits are 7 to 12 millimeters (0.3 to 0.5 inches) long and contain numerous white seeds. This species differs from other taxa of the genus by the shape, length, and margins of the leaves and by having hairs at the base of the

anthers (Hillebrand 1888; Lammers 1990; Rock 1913, 1919; Wimmer 1953).

b. Life History

Little is known about the life history of *Delissea rhytidosperma*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species generally grows in diverse lowland mesic forests or koa-dominated lowland dry forests that have well-drained soils with medium- to fine-textured subsoil. Associated native plant taxa includes *Dianella sandwicensis* (ukiuki), lama, *Nestegis sandwicensis* (olopua), and pukiawe (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Delissea rhytidosperma*.

Historically, *Delissea rhytidosperma* was known from scattered locations throughout the island of Kauai. Populations ranged as far north as Wainiha and Limahuli Valleys, as far east as Kapaa and Kealia, and as far south as Haupu Range between the elevations of 300 and 1,000 meters (1,000 and 3,000 feet) (HHP 1994). Today only two populations still exist. One population, located in State-owned Kuia NAR, contains six individuals (HHP 1994; USFWS 1994a). It was thought that Hurricane Iniki completely destroyed the population of 20 plants in the Haupu range in 1992 (Perlman 1992, USFWS 1994a); however, this population still has four plants and nine seedlings (S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The major threats to *Delissea rhytidosperma* are predation and/or habitat degradation by mule deer or black-tailed deer, feral goats, and feral pigs. Other threats are predation by rats and slugs, fire, over-collecting for scientific or horticultural purposes, and competition with alien plants (lantana, *Passiflora ligularis* (sweet granadilla), *Cordyline fruticosa* (ti), and *Passiflora mollissima* (banana poka)). This species is also threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (USFWS 1994a).

f. Conservation Measures

Delissea rhytidosperma has been successfully propagated and grown *ex situ* by Lyon Arboretum, NTBG, and Waimea Arboretum. Present holdings at Lyon Arboretum consist of 93 plants in the tissue culture lab and one plant in the certified greenhouse (C. Lamoureux, personal communication 1995). NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995), and Waimea Arboretum has 19 plants and 100 seedlings (J. Llop, personal communication 1995). No additional conservation measures are being conducted for *Delissea rhytidosperma* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from mule deer or black-tailed deer, feral goats, and feral pigs. Please refer to the

Stepdown Narrative section of this plan for the overall recovery strategy.

6. *Diellia pallida* - RP# 5

a. Description and Taxonomy

There is no line drawing available for *Diellia pallida*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

About 1875, Valdemar Knudsen, a rancher on Kauai, collected a fern at Halemanu, which Wilhelm Hillebrand (1888) named *Lindsaya laciniata*, the specific epithet referring to the divided fronds. Hillebrand also indicated two varieties: var. *subpinnata*, a bipinnate form, which may actually represent another species (Wagner 1952), and an unnamed form. Friedrick Ludwig Emil Diels (1899) transferred the species to *Diellia*, resulting in *Diellia laciniata*, the name in use at the time the species was proposed for listing under the ESA (Lamoureux 1988). Recent studies have recognized these populations as a new species, *Diellia pallida* (W.H. Wagner 1993).

Diellia pallida, a member of the spleenwort family (Aspleniaceae), is a plant that grows in tufts of three to four light green, lance-shaped fronds along with a few persistent dead ones. The midrib of the frond ranges from dark purple to brownish gray in color and has a dull sheen. Scales on the midrib are brown, gray, or black; 3 to 5 millimeters (0.1 to 0.2 inches) long; and rather inconspicuous. The fronds measure 30 to 55 centimeters (12 to 22 inches) in length and 5 to 12 centimeters (2 to 5 inches) in width and have short black hairs on the underside. Each frond has approximately 20 to 40 pinnae (divisions or leaflets). The largest pinnae are in the middle section of the frond, while the lower section has triangular, somewhat reduced

pinnae, with the lowermost pair of pinnae raised above the plane of the others. The sori (groups of spore-producing bodies), which are frequently fused along an extended line, are encircled by a prominent vein. This species differs from others of this endemic Hawaiian genus by the color and sheen of the midrib, the presence and color of scales on the midrib, and the frequent fusion of sori (Hillebrand 1888; Wagner 1952, 1987).

b. Life History

Little is known about the life history of *Diellia pallida*. Reproductive cycles, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species grows on bare soil on steep, rocky, dry slopes of lowland mesic forests, 530 to 690 meters (1,700 to 2,300 feet) in elevation. Associated plant taxa include koa, *Alectryon macrococcus* (mahoe), kukui, hame, ohia, *Myrsine lanaiensis* (kolea), and *Rauvolfia sandwicensis* (hao) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Diellia pallida*.

Diellia pallida was known historically from Halemanu on Kauai (Hillebrand 1888). This species had not been seen since 1949, until a collection was made in Kuia NAR (USFWS 1994a). In 1987, Joel Lau discovered the Koaie Canyon population which at that time contained three or four individuals (Bruegmann 1990, HHP 1994, USFWS 1994a). Another population (two individuals) was discovered by NTBG botanists on the west side of Waimea Canyon within Puu Ka Pele Forest Reserve, but the plants have since disappeared and were likely destroyed by goats (CPC 1989, 1990;

HHP 1994; Wagner 1952; USFWS 1994a; Lorence and Flynn 1991). *Diellia pallida* is currently known from three populations on State land within Kuia NAR (Mahanaloa Valley and Makaha Valley) and Koaie Canyon. These populations extend over a 5- by 11-kilometer (3- by 7-mile) area (NTBG 1994, Perlman 1992, USFWS 1994a). Recent visits to these populations have found a total of 23 individuals, with 1 individual at Koaie Canyon, 10 individuals at Mahanaloa Valley, and 12 individuals (4 adults and 8 juveniles) at the Makaha Valley population (S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The major threats to *Diellia pallida* include competition with alien plants (lantana, *Melia azedarach* (Chinaberry), St. Augustine grass, *Oplismenus hirtellus* (basketgrass), kukui and ti), and predation and habitat degradation by feral goats, feral pigs and mule deer. Other threats include fire, over-collecting for scientific purposes, as well as stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (USFWS 1994a).

f. Conservation Measures

No specific conservation measures are being conducted for *Diellia pallida* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from mule deer, feral goats, feral pigs and alien weed threats. Please refer to the

Stepdown Narrative section of this plan for the overall recovery strategy.

7. ***Dubautia latifolia*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Dubautia latifolia*.

The information in this section is taken directly from the listing package covering six of the Kauai cluster taxa (USFWS 1992a).

Dubautia latifolia was first collected in the mountains of Kauai by the U.S. Exploring Expedition in 1840 (Carr 1982). Twenty-one years later, Asa Gray (1861) described that specimen as *Raillardia latifolia* (an orthographic error for *Railliardia latifolia*, as Sherff pointed out in 1935), in reference to its broad leaves. In 1936, David Keck transferred the name to the genus *Dubautia*. Sherff published the name *Railliardia latifolia* var. *helleri* in 1952, which Gerald Carr (1985) considered only a phenological variant not worthy of taxonomic recognition.

Dubautia latifolia is a diffusely branched, woody vine in the aster family (Asteraceae) with stems up to 8 meters (26 feet) long and occasionally up to 7 centimeters (3 inches) in diameter near the base. The paired, egg- to oval-shaped leaves are 8 to 17 centimeters (3 to 7 inches) long and 2.5 to 7 centimeters (1 to 3 inches) wide. The leaves are conspicuously net-veined, with the smaller veins outlining nearly square areas. The distinct petioles are usually about 5 millimeters (0.2 inches) long. The inflorescences comprise a large aggregation of very small, yellow-flowered heads. The fruits are dry seeds, usually about 5 millimeters (0.2 inches) long. A vining habit, distinct petioles, and broad leaves with conspicuous net veins outlining squarish areas separate *Dubautia latifolia* from closely related species (Carr 1982, 1985, 1990).

b. Life History

This taxon appears to be self-incompatible. Since at least some individuals of *D. latifolia* require cross-pollination, the wide spacing of individual plants (e.g., each 0.5 kilometers (0.3 miles) apart) may pose a threat to the reproductive potential of the species (Carr 1982b). The very low seed set noted in plants in the wild indicates a reproductive problem, possibly flowering asynchrony (Carr 1992b). Seedling establishment is also rare and young plants are rarely seen. *Dubautia latifolia* experiences seasonal vegetative decline during the spring and summer often losing most of its leaves. New growth and flowering occur in the fall with fruits developing in November. Pollinators and seed dispersal agents are unknown (Carr 1982b).

c. Habitat Description

Dubautia latifolia typically grows on gentle to steep slopes on well drained soil in semi-open, diverse montane mesic forest dominated by koa and ohia, at an elevation of 975 to 1,200 meters (3,200 to 3,900 feet). Less often, this species is found in either closed forest, conifer plantations, or ohia-dominated forest, and as low as 850 meters (2,800 feet) in elevation. The most common associated native species are kauila, *Athyrium sandwicensis*, *Bobea* (ahakea), *Coprosma waimeae* (olena), uluhe, *Hedyotis terminalis* (manono), *Ilex anomala* (aiea), *Melicope anisata* (mokihana), *Psychotria mariniana* (kopiko), and *Scaevola* (naupaka kuahiwi). Associated alien species include prickly Florida blackberry, strawberry guava, *Acacia mearnsii* (black wattle), *Acacia melanoxylon* (Australian blackwood), *Erigeron karvinskianus* (daisy fleabane), ginger, *Lonicera japonica* (Japanese honeysuckle), *Myrica faya* (firetree), and banana poka (USFWS 1992a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current distribution of *Dubautia latifolia*.

All collections and confirmed sightings of this species are from six areas on the island of Kauai: Makaha, Awaawapuhi, Waialae, Kawaiula and Kauhau Valleys in Na Pali-Kona Forest Reserve; Nualolo Trail and Valley in Kuia NAR; Halemanu in Kokee State Park; along Mohihi Road in both Kokee State Park and Na Pali-Kona Forest Reserve; along the Mohihi-Waialae Trail on Mohihi and Kohua ridges in both Na Pali-Kona Forest Reserve and Alakai Wilderness Preserve; and at Kaholuamanu on privately owned land (Carr 1982b; HHP 1994; USFWS 1992a; S. Perlman, personal communication 1994). *Dubautia latifolia* is currently known from all but the Halemanu and Kaholuamanu sites and the total number of individuals is more than 100. All current populations are on State-owned land (USFWS 1992a; S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The greatest immediate threat to the survival of *Dubautia latifolia* is competition from alien plants. Banana poka is the greatest threat to four populations, while prickly Florida blackberry, Japanese honeysuckle, black wattle, Australian blackwood, ginger, daisy fleabane, and strawberry guava also dominate the habitat of and/or threaten *D. latifolia*. *D. latifolia* is also threatened by feral ungulates (feral pigs threaten four populations and black-tailed deer threaten two populations). Vehicle traffic and road maintenance constitute a potential threat to several individuals that overhang a State park road. This species suffers from seasonal dieback that could be a potential threat. In addition, *Dubautia latifolia* is threatened by the small number of extant individuals and restricted distribution (USFWS 1992a).

f. Conservation Measures

Dubautia latifolia has been successfully propagated by NTBG, and the garden presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Dubautia latifolia* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

8. ***Exocarpos luteolus*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Exocarpos luteolus*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Reverend John Mortimer Lydgate first collected *Exocarpos luteolus* in 1908, and Charles N. Forbes (1910) described the species 2 years later. The specific epithet means "yellow" and refers to the color of the receptacle (base of flower) and fruit.

Exocarpos luteolus, a member of the sandalwood family (Santalaceae), is a moderately to densely branched shrub 0.5 to 2 meters (1.6 to 6.6 feet) tall with knobby branches. The leaves are of two kinds, minute scales and more typical leaves. The latter, which are usually present, are elliptical, lance-shaped, or oval, usually 5 to 8 centimeters (2 to 3.2 inches) long and 25 to 36 millimeters (1 to 1.4 inches) wide, and lack a leaf stalk. The green flowers have five to six petals about 1 millimeter (0.04

inches) long. The pale yellow fruit is a drupe (single-seeded fleshy fruit), usually 11 to 19 millimeters (0.4 to 0.7 inches) long, with four distinct indentations at the apex. About 6 to 9 millimeters (0.2 to 0.4 inches) of the drupe is exposed above the fleshy, golden-yellow receptacle. This species is distinguished from others of the genus by its generally larger fruit with four indentations and by the color of the receptacle and fruit (Degener 1932a, 1932b; Forbes 1910; Wagner et al. 1990).

b. Life History

Little is known about the life history of *Exocarpos luteolus*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Exocarpos luteolus is found at elevations between 600 and 1,100 meters (2,000 and 3,600 feet) in a variety of habitats: wet places bordering swamps; on open, dry ridges; and lowland to montane, ohia-dominated wet forest communities. Associated taxa include koa, pukiawe, and uluhe (USFWS 1994a). This taxon has a scattered distribution and tends to grow at habitat edges where there is adequate light (Loyal Mehrhoff, USFWS, personal communication 1995).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Exocarpos luteolus*.

Historically, *Exocarpos luteolus* was known from three locations on Kauai: Wahiawa Swamp, Kaholuamanu, and Kumuwela Ridge (HHP 1994). This species is now known to grow on Kumuwela Ridge, Kauaikinana Valley, near Honopu Trail, Waialae, and on the rim of

Kalalau Valley within or on the boundary of Kokee State Park (HHP 1994, Lorence and Flynn 1991) in a 5 square kilometer (3 square mile) area, and on Kamalii Ridge in Kealia Forest Reserve, roughly 26 kilometers (16 miles) away (HHP 1994). There are also extant populations in the Na Pali Kona Forest Reserve (Nawaimaka, Pohakuao, Koaie Canyon, and Awaawapuhi), the Alakai Swamp, and the Wahiawa Mountains. The 12 known populations are scattered on State land and are estimated at 324-349 individuals (HHP 1994; USFWS 1994a; Lorence and Flynn 1991; S. Perlman, personal communication 1995). There are reliable but unconfirmed reports that this species was collected on the slopes of Anahola Mountain about 1970 (USFWS 1994a).

e. Reasons for Decline and Current Threats

The major threats to *Exocarpos luteolus* are feral goats and pigs, competition with alien plants (daisy fleabane, black wattle, *Corynocarpus laevigatus* (karakanut), firetree, and prickly Florida blackberry), rats, fire, erosion, and over-collecting for scientific purposes (USFWS 1994a).

f. Conservation Measures

Exocarpos luteolus has been successfully propagated by NTBG and the garden presently has seeds in short-term storage (D. Ragone, personal communication 1995). Present holdings at Lyon Arboretum consist of seeds in the tissue culture lab (C. Lamoureux, personal communication 1995). The Kauai District DOFAW is planning a plant sanctuary project in the Kalalau Rim area which will include fencing and other management (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Exocarpos luteolus* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Recent surveys indicate that the Alakai Swamp populations of this taxon are threatened by feral pigs. Fencing of the Waikoali Bog complex will protect several populations of *Exocarpos luteolus* and other rare taxa from pig damage (L. Mehrhoff, personal communication 1995). Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

9. ***Hedyotis cookiana*** - RP# 5

a. Description and Taxonomy

There is no line drawing available for *Hedyotis cookiana*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Louis Charles Adelbert von Chamisso collected a plant specimen in 1816 at Kealakekua, island of Hawaii, and named it *Kadua cookiana* (Chamisso and Schlechtendal 1829). The specific epithet commemorates Captain James Cook, the first European to anchor at Kealakekua Bay. Ernest G. Steudel (1840) transferred the species to the genus *Hedyotis*, resulting in the combination *H. cookiana*.

Hedyotis cookiana, a member of the coffee family (Rubiaceae), is a small shrub with many branches 10 to 20 centimeters (4 to 8 inches) long. The papery-textured leaves are long and narrow, 4 to 8 centimeters (1.5 to 3 inches) long and about 0.5 to 1.2 centimeters (0.2 to 0.5 inches) wide, and fused at the base to form a sheath around the stem. The bisexual or female flowers are arranged in clusters of threes on flower stalks about 8 to 15 millimeters (0.3 to 0.6 inches) long, with the central flower on the longest stalk. Beneath the flower clusters are sharp-pointed bracts (modified leaves). The fleshy white

corolla is trumpet-shaped and about 8 to 9 millimeters (0.3 to 0.4 inches) long, with lobes about 2 millimeters (0.08 inches) long. Fruits are top-shaped or spherical capsules about 3.0 to 3.5 millimeters (0.1 inches) long and 3.5 to 4 millimeters (0.1 to 0.2 inches) wide that open at maturity to release wedge-shaped reddish brown seeds. This plant is distinguished from other species in the genus that grow on Kauai by being entirely hairless (Fosberg 1943, Hillebrand 1888, Chamisso and Schlechtendal 1829, Wagner et al. 1990).

b. Life History

Little is known about the life history of *Hedyotis cookiana*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Hedyotis cookiana generally grows in streambeds or on steep cliffs close to water sources in lowland wet forest communities. This species is believed to have formerly been much more widespread on several of the main Hawaiian Islands at elevations between 170 and 370 meters (560 and 1,200 feet) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Hedyotis cookiana*.

Historically, *Hedyotis cookiana* was known from only three collections: Kealakekua on the island of Hawaii, Halawa and Kalawao on Molokai, and at the foot of the Koolau Mountains on Oahu (Fosberg 1943, HHP 1994, Hillebrand 1888). There is no evidence that it still exists on any of those islands. This species was discovered in 1976 by Charles Christensen on the

island of Kauai in Waiahuakua Valley on State land (HHP 1994). The Waiahuakua population is still extant, and it contains 50 to 100 plants that are scattered along a 0.4-kilometer (0.25-mile) distance in the streambed and lower part of the waterfall (S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The major threat to *Hedyotis cookiana*, with only one known population, is stochastic extinction and/or reduced reproductive vigor. Individuals of *Hedyotis cookiana* grow in a stream bed and on the side of a waterfall, and these areas are vulnerable to flooding and other natural disturbances. Other potential threats include competition with alien plants, and habitat modification by feral pigs and goats, which have been observed in the area (USFWS 1994a).

f. Conservation Measures

Hedyotis cookiana has been successfully propagated and grown *ex situ* by NTBG. NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Hedyotis cookiana* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats, feral pigs and competition from alien weeds. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

10. *Hedyotis st.-johnii* - RP# 8

a. Description and Taxonomy

Appendix B contains a line drawing of *Hedyotis st.-johnii*.

The information in this section is taken directly from the listing package covering two of the Kauai cluster taxa (USFWS 1991a).

Hedyotis st.-johnii was first collected in 1947 by Harold St. John, E.J. Britten, and R.S. Cowan on the vertical sea cliffs between Kalalau and Honopu valleys on Kauai. The next collection was made by B.C. Stone in 1956 from the same location. Two years later Stone and I. Lane (1958) described the plant as a new species, naming it in honor of its discoverer.

Hedyotis st.-johnii is a succulent perennial herb of the coffee family (Rubiaceae) with slightly woody, trailing, quadrangular stems up to 30 centimeters (1 foot) long. The fleshy leaves are clustered toward the base of the stem and are broadly ovate to broadly elliptic, 5.5 to 15 centimeters (2 to 6 inches) long and about 3.5 to 7.5 centimeters (2 inches) wide. Clusters of flowers are borne on 7 to 15 centimeter (3 to 6 inch) long flowering stems. The leafy, broadly ovate calyx lobes are about 3 to 4 millimeters (0.1 inches) long and wide, enlarging in fruit to about 8 to 11 millimeters (0.4 inches) long and wide. The green petals are fused into a tube about 5 to 8 millimeters (0.2 inches) long and wide. The fruit consists of kidney-shaped capsules with dark brown to blackish angular seeds. *Hedyotis st.-johnii* is distinguished from related species by its succulence, basally clustered fleshy leaves, shorter floral tube, and large leafy calyx lobes when in fruit (Wagner et al. 1990).

b. Life History

Little is known about the life history of *Hedyotis st.-johnii*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Hedyotis st.-johnii grows in the crevices of north-facing, near-vertical coastal cliff faces within the spray zone (below 75 meters (250 feet)). The associated vegetation is sparse dry coastal shrubland and includes species such as the native *Artemisia australis* (ahinahina) and akoko, and the alien *Pluchea symphytifolia* (sourbush) (USFWS 1991a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Hedyotis st.-johnii*.

The most recent collections of *Hedyotis st.-johnii* have been from a 7.2-kilometer (4.5-mile) long section of the Na Pali coast: between Kalalau and Honopu beaches, and from Nualolo Valley, Nualolo Kai, and Milolii Beach. Another population containing 2 groups totaling 10 individuals was discovered on Polihale ridge in 1991. *Hedyotis st.-johnii* is still extant in all of those areas except perhaps Nualolo Kai, which has not been resurveyed in 11 years (USFWS 1991a). Fewer than 200 individuals have been seen in these 4 populations, with some populations numbering as low as 1 plant (Corn 1984, HHP 1994, NTBG 1994). Similar, inaccessible habitat might harbor as yet undiscovered individuals (USFWS 1991a). Known only from State-owned land, *Hedyotis st.-johnii* is restricted to Na Pali Coast State Park.

e. Reasons for Decline and Current Threats

Goat predation and habitat degradation are the major causes for the decline of this species. As a result of past goat activity, *Hedyotis st.-johnii* is now almost entirely restricted to sites inaccessible to goats. The major current threat is competition from alien plant species, especially sourbush. Other potential threats are landslides and fire (USFWS 1991a).

f. Conservation Measures

Hedyotis st.-johnii has been successfully propagated and grown *ex situ* by NTBG, and NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Hedyotis st.-johnii* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

11. ***Hibiscus clayi*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Hibiscus clayi*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

In 1928, Albert W. Duvel discovered several trees of *Hibiscus clayi* that had been damaged by cattle and brought the species into cultivation. Isa and Otto Degener named the species

after the late Horace F. Clay, a horticulturist and college instructor who brought the species to their attention (Degener and Degener 1959c). Sister Margaret James Roe, in her study of the genus in Hawaii, named *Hibiscus newhousei* as another species from Kauai (Roe 1959, 1961). In the currently accepted treatment of the Hawaiian members of the family, David M. Bates (1990) considers *H. newhousei* to be a synonym of *H. clayi*.

Hibiscus clayi, a member of the mallow family (Malvaceae), is a shrub or tree 4 to 8 meters (13 to 26 feet) tall with stems bearing sparse hairs at the branch tips. The oval or elliptical leaves are usually 3 to 7 centimeters (1 to 3 inches) long and 15 to 35 millimeters (0.6 to 1.4 inches) wide and have a hairless upper surface and slightly hairy lower surface. The leaf margins are entire or toothed toward the apex. The flowers are borne singly near the ends of the branches. The flaring petals are dark red, 45 to 60 millimeters (1.8 to 2.4 inches) long, and 10 to 18 millimeters (0.4 to 0.7 inches) wide. The green tubular or urn-shaped calyx is usually 15 to 25 millimeters (0.6 to 1 inches) long with five or six shorter bracts beneath. The fruits are pale brown capsules 12 to 14 millimeters (0.5 to 0.6 inches) long, containing about 10 oval, brownish black seeds about 4 millimeters (0.16 inches) long. This species is distinguished from other native Hawaiian members of the genus by the lengths of the calyx, calyx lobes, and capsule and by the margins of the leaves (Bates 1990, Degener and Degener 1959c).

b. Life History

Little is known about the life history of *Hibiscus clayi*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This lowland dry forest species generally grows on slopes at an elevation of 230 to 350 meters (750 to 1,150 feet). Associated taxa include *Syzgium cumini* (Java plum), koa, kukui, and ti (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of historic and current range of *Hibiscus clayi*.

Hibiscus clayi is known from scattered locations on private and State land on the island of Kauai: the Kokee region on the western side of the island, Moloaa Valley to the north, Nounou Mountain in Wailua to the east, and as far south as Haiku near Halii Stream (HHP 1994). At this time, only the Nounou Mountains population, with four trees, is known to still exist (HHP 1994, USFWS 1994a, Lorence and Flynn 1991). It is unclear whether the one individual from the Kokee region was a cultivated plant.

e. Reasons for Decline and Current Threats

Before cattle were removed from the area, they greatly damaged the habitat of *Hibiscus clayi*. The major current threat is competition with alien plant taxa. Strawberry guava is the greatest threat, but common guava, Hilo grass, basketgrass, Java plum, kukui, lantana, ti, and *Schinus terebinthifolius* (Christmas berry) are also present. The area of the Nounou Mountain population has been planted with *Araucaria columnaris* (columnar araucaria), which is reproducing and may prevent regeneration of native plants. The close proximity of most of the plants to a hiking trail makes them prone to human disturbance. Pigs pose a potential threat to the species. The small total number of existing individuals poses a threat of stochastic extinction and/or reduced reproductive vigor (USFWS 1994a).

f. Conservation Measures

Hibiscus clayi has been successfully propagated and grown *ex situ* by Lyon Arboretum, NTBG, and Waimea Arboretum. Present holdings at Lyon Arboretum consist of two plants in the nursery and 22 plants on Lyon Arboretum grounds (C. Lamoureux, personal communication 1995). NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995), and Waimea Arboretum has 21 plants and 100 seedlings (J. Llop, personal communication 1995).

The Kauai District DOFAW has outplanted 11 *Hibiscus clayi* at Kalepa and Nounou Forest Reserves (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Hibiscus clayi* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral pigs and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

12. ***Lipochaeta fauriei*** - RP# 5

a. Description and Taxonomy

There is no line drawing available for *Lipochaeta fauriei*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Abbe Urbain Jean Faurie first collected *Lipochaeta fauriei* on Kauai in 1910, and the following year H. Leveille (1911) named the plant in honor of him. St. John (1972) described another species from Kauai, *L. deltoidea*, but the authors of the current treatment place this name in synonymy with *L. fauriei* (Wagner et al. 1990).

Lipochaeta fauriei, a member of the aster family (Asteraceae), is a perennial herb with somewhat woody, erect or climbing stems up to 5 meters (16 feet) long. The toothed leaves are narrowly triangular, slightly hairy, 7 to 13 centimeters (3 to 5 inches) long, and about 3 centimeters (1.2 inches) wide. Flower heads occur in clusters of 2 to 3, each comprising 6 to 8 ray florets, 6 to 13 millimeters (0.2 to 0.5 inches) long and about 2.3 millimeters (0.1 inches) wide, and 30 to 35 disk florets 3.3 to 3.9 millimeters (0.1 to 0.2 inches) long. The bracts beneath the flower heads are purple near the base. Fruits are knobby-textured achenes (dry, one-seeded fruits) about 2.5 to 3 millimeters (0.1 inches) long and 1.5 to 2 millimeters (0.07 inches) wide, the achenes of the disk florets are sometimes thinner and shorter than those of the ray florets. This species belongs to a genus endemic to the Hawaiian Islands and is one of three species found only on the island of Kauai. This species differs from the others on Kauai by having a greater number of disk and ray flowers per flower head, typically longer leaves and leaf stalks, and longer ray flowers (Gardner 1976, 1979; St. John 1972; Sherff 1935a; Wagner et al. 1985, 1990).

b. Life History

Little is known about the life history of *Lipochaeta fauriei*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species most often grows in moderate shade to full sun and is usually found on the sides of steep gulches in diverse lowland mesic forests at an elevation of about 480 to 900 meters (1,570 to 2,950 feet). The associated native plant taxa include lama and *Hibiscus waimeae* (kokio keokeo) and associated alien plants include basketgrass, kukui and lantana (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Lipochaeta faurei*.

Historically, *Lipochaeta fauriei* was known from Olokele Canyon on the island of Kauai (Gardner 1979, HHP 1994). This species is now also known from three other areas on Kauai: Poopooiki, Haeleele, and lower Hikimoe Valleys (HHP 1994, NTBG 1994, St. John 1972). A population in Koaie Canyon that was previously thought to be *Lipochaeta fauriei* is *Lipochaeta subcordata* (USFWS 1994a; S. Perlman, personal communication 1994). All three populations, totalling fewer than 70 individuals, are found on State land (HHP 1994, NTBG 1994, USFWS 1994a), encompassing a 10- by 11-kilometer (6- by 7-mile) area.

e. Reasons for Decline and Current Threats

The major threats to *Lipochaeta fauriei* are predation and habitat degradation by feral goats and competition with invasive alien plant taxa (lantana, common guava, strawberry guava, molasses grass, basketgrass). Feral pigs pose a potential threat to the species. Fire is a significant threat because *Lipochaeta fauriei* occurs with molasses grass, a fire-adapted alien grass. The small total number of individuals comprises a threat of stochastic extinction and/or reduced reproductive vigor to this species (USFWS 1994a).

f. Conservation Measures

Lipochaeta fauriei has been successfully propagated and grown *ex situ* by NTBG, and NTBG presently has plants growing in their garden (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Lipochaeta fauriei* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats, alien weed threats and fire. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

13. ***Lipochaeta micrantha* var. *exigua*** - RP# 6

a. Description and Taxonomy

No line drawing is available for *Lipochaeta micrantha* var. *exigua*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Thomas Nuttall (1841) described *Schizophyllum micranthum* based upon a specimen collected on Kauai in 1840 during the United States Exploring Expedition. The specific epithet refers to the small size of the flowers. In 1843 Guilielmo Gerardo Walpers published the superfluous name *Aphanopappus nuttallii* based upon the same specimen described by Nuttall (Gardner 1979). Gray (1861) transferred the species to the genus *Lipochaeta*, resulting in *L. micrantha*. Amos Arthur Heller (1897) transferred the

species into the genus *Aphanopappus*, resulting in *A. micranthus*. Otto Degener and Earl Edward Sherff (Sherff 1941) described *L. exigua* as another Kauai taxon based upon a specimen collected by Otto Degener and Emilio Ordonez. In his monograph of the genus, Robert C. Gardner (1979) recognized *L. micrantha* var. *exigua* along with the typical variety, and this is accepted in the current treatment (Wagner et al. 1990).

Lipochaeta micrantha, a member of the aster family, is a somewhat woody perennial herb. The 0.5 to 2 meter (1.6 to 6.6 foot) long stems grow along the ground and root at the nodes, with the tip of the stem growing upward. The roughly triangular leaves measure 2.1 to 9.7 centimeters (0.8 to 3.8 inches) long and 1.2 to 7.8 centimeters (0.5 to 3.1) inches wide. They are sparsely hairy, with margins smooth or variously lobed. Flower heads are in clusters of 2 or three. Each head contains four to five ray florets, 2.3 to 5.8 millimeters (0.1 to 0.2 inches) long and 1.4 to 3.5 millimeters (0.06 to 0.14 inches) wide, and five to nine disk florets, about 2.7 to 3.1 millimeters (0.1 inches) long. The 2 recognized varieties of this species, *exigua* and *micrantha*, are distinguished by differences in leaf length and width, degree of leaf dissection, and the length of the ray florets. The smaller number of disk florets separates this species from the other members of the genus on the island of Kauai (Gardner 1976, 1979; Degener and Degener 1959b, 1962; Sherff 1935a; Wagner et al. 1990).

b. Life History

Little is known about the life history of *Lipochaeta micrantha* var. *exigua*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This taxon grows in diverse mesic forest at an elevation of 300 to 400 meters (980 to 1,310 feet) (Wagner et al. 1990). Associated plant taxa include alahee, lama, ohia, *Chamaesyce celastroides* var. *hanapepensis* (akoko), and *Neraudia kauaiensis* (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Lipocheta micrantha* var. *exigua*.

Only two populations of *Lipochaeta micrantha* var. *exigua* are known, from the vicinity of Haupu Range on the island of Kauai (HHP 1994). The populations of this variety are distributed over a 2.4-kilometer (1.5-mile) distance on privately owned portions of Haupu Range and total between 100 and 500 individuals (HHP 1994, NTBG 1994, USFWS 1994a).

e. Reasons for Decline and Current Threats

The major threats to *Lipochaeta micrantha* var. *exigua* are habitat degradation by feral pig and competition with alien plant taxa such as lantana and sourbush. *Lipochaeta micrantha* var. *exigua* is also threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing populations (USFWS 1994a).

f. Conservation Measures

Lipochaeta micrantha var. *exigua* has been successfully propagated and grown *ex situ* by NTBG, and NTBG presently has plants growing in their garden (D. Ragone, personal communication 1995). No additional conservation measures are being conducted

for *Lipochaeta micrantha* var. *exigua* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral pigs and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

14. ***Lipochaeta micrantha* var. *micrantha*** - RP# 9

a. Description and Taxonomy

Appendix B contains a line drawing of *Lipochaeta micrantha* var. *micrantha*.

Please refer to the section on Description and Taxonomy for *Lipochaeta micrantha* var. *exigua*.

b. Life History

Little is known about the life history of *Lipochaeta micrantha* var. *micrantha*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Appendix C contains a map of the historic and current range of *Lipocheta micrantha* var. *micrantha*.

This taxon grows in diverse mesic forest at an elevation of 300 to 400 meters (980 to 1,310 feet) (Wagner et al. 1990).

Associated plant taxa include alahee, lama, ohia, *Chamaesyce celastroides* var. *hanapepensis* (akoko), and *Neraudia kauaiensis* (USFWS 1994a).

d. Historic and Current Range and Population Status

Lipochaeta micrantha var. *micrantha* appears to have been more widely distributed historically on Kauai than *Lipochaeta micrantha* var. *exigua*: Olokele Canyon, Hanapepe Valley, and in the Koloa District (HHP 1994, NTBG 1994, USFWS 1994a). This variety is now known only from two to four populations located on State land in Koaie Canyon on Kauai, totalling 150-570 individuals (CPC 1992, HHP 1994, USFWS 1994a). The populations encompass an area of 2.3 kilometers (1.4 miles) approximately 2.3 kilometers (1.4 miles) apart.

e. Reasons for Decline and Current Threats

The major threats to *Lipochaeta micrantha* var. *micrantha* are habitat degradation by feral ungulates and competition with alien plant taxa. Feral pigs are a significant threat, and signs of damage by feral goats have been seen near individuals. Alien plant taxa such as lantana, daisy fleabane, and *Stachytarpheta* affect the habitats of this taxon. *Lipochaeta micrantha* var. *micrantha* is also threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing populations (USFWS 1994a).

f. Conservation Measures

Lipochaeta micrantha var. *micrantha* has been successfully propagated and grown *ex situ* by Lyon Arboretum, NTBG, and Waimea Arboretum. Present holdings at Lyon Arboretum consist of 36 plants in the nursery (C. Lamoureux, personal communication 1995). NTBG presently has plants growing in their garden (D. Ragone,

personal communication 1995), and Waimea Arboretum has 26 plants and 10 cuttings (J. Llop, personal communication 1995). No additional conservation measures are being conducted for *Lipochaeta micrantha* var. *micrantha* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

15. *Lipochaeta waimeaensis* - RP# 2

a. Description and Taxonomy

Appendix B contains a line drawing of *Lipochaeta waimeaensis*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Hobdy collected the first specimen of *Lipochaeta waimeaensis* in 1967, and 5 years later St. John (1972) described it as a new species, naming it for the Waimea Canyon where it grows.

Lipochaeta waimeaensis, a member of the aster family, is a low growing, somewhat woody perennial herb with stems 1 to 2 meters (3 to 6.5 feet) long that root at the nodes. The linear or narrowly elliptical leaves are 4.7 to 5 centimeters (1.9 to 2 inches) long, 5 to 8 millimeters (0.2 to 0.3 inches) wide, hairy along major veins on the upper surface, and evenly hairy on the lower surface. Flower heads are borne singly or in clusters of two or three. The outer head bracts are lance-shaped and measure 3 to 4 millimeters (0.1 to 0.2 inches) long and 1.5 to 2 millimeters (0.06 to 0.08 inches) wide. The oval ray florets number four or five per head and are about 3.2 to 3.5 millimeters (0.13 inches) long and about 3 millimeters (0.1 inches) wide. The

disk florets number 20 to 25 per head. The fruits are knobby, winged achenes 2.2 to 2.5 millimeters (0.1 inches) long and about 1.7 to 2.3 millimeters (0.08 inches) wide. The ray achenes are slightly wider and have longer wings than those of the disk. This species differs from the two other taxa of the genus included in this rule (*L. fauriei* and *L. micrantha*) in having a different leaf shape and shorter leaf stalks and ray florets (Gardner 1976, 1979; St. John 1972; Wagner et al. 1990).

b. Life History

Little is known about the life history of *Lipochaeta waimeaensis*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This population grows on eroded soil on a precipitous, shrub-covered gulch in a diverse lowland mesic forest at an elevation between 350 and 400 meters (1,150 and 1,300 feet). The vegetation at the site is predominantly alien consisting of *Grevillea robusta* (silk oak), *Leucaena leucocephala* (koa haole), and *Rhynchelytrum repens* (Natal redtop); however, the native taxa aalii and *Lipochaeta connata* (nehe) also occur here (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Lipochaeta waimeaensis*.

Lipochaeta waimeaensis is known only from the type locality, along the rim of Kauai's Waimea Canyon on State land (HHP 1994; NTBG 1994). An estimated 100 or more plants are scattered over a 1-hectare (2.5-acre) area (S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The major threat to *Lipochaeta waimeaensis* is competition from alien plants such as koa haole, Natal redtop, silk oak, and *Opuntia ficus-indica* (prickly pear). The existing soil erosion problem is exacerbated by the presence of feral goats. The single population, and thus the entire species, is threatened by stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals. Over-collecting for scientific purposes also poses a threat (USFWS 1994a).

f. Conservation Measures

Lipochaeta waimeaensis has been successfully propagated and grown *ex situ* by Lyon Arboretum and NTBG. Present holdings at Lyon Arboretum consist of 28 plants on the arboretum grounds (C. Lamoureux, personal communication 1995). NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Lipochaeta waimeaensis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

16. *Lysimachia filifolia* - RP# 2

a. Description and Taxonomy

There is no line drawing available for *Lysimachia filifolia*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

In 1912 Lydgate collected a plant specimen on Kauai which he and Forbes named *Lysimachia filifolia* (Forbes 1916). They chose the specific epithet, which means "thread-leaved," in reference to the plant's very narrow leaves. Heller (1897) created a new genus, *Lysimachiopsis*, in which he placed all endemic Hawaiian taxa of *Lysimachia*, and Otto and Isa Degener (1983) later published *Lysimachiopsis filifolia*. The current treatment (Wagner et al. 1990) recognizes *Lysimachiopsis* as a section of *Lysimachia*. Most recently, St. John (1987b) published many species, varieties, and combinations of *Lysimachia*, one or more of which may fit into this species (Wagner et al. 1990).

Lysimachia filifolia, a member of the primrose family (Primulaceae), is a small shrub 15 to 50 centimeters (0.5 to 1.6 feet) tall. The linear leaves measure 15 to 54 millimeters (0.6 to 2.1 inches) long and 0.3 to 1.8 millimeters (0.01 to 0.07 inches) wide and are usually alternately arranged. They are single-veined and sparsely hairy or hairless. The bell-shaped flowers are reddish purple, 6 to 10 millimeters (0.2 to 0.4 inches) long, and borne singly on flower stalks about 18 to 30 millimeters (0.7 to 1.2 inches) long that elongate upon fruiting. Fruits are thick, hard capsules about 5 to 6 millimeters (0.2 inches) long that contain numerous minute, nearly black, irregularly shaped seeds. This species is distinguished from other taxa of the genus by its leaf shape and width, calyx lobe shape, and corolla length (Forbes 1916, Wagner et al. 1990).

b. Life History

Little is known about the life history of *Lysimachia filifolia*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species typically grows on mossy banks at the base of cliff faces within the spray zone of waterfalls or along streams in lowland wet forests at an elevation of 240 to 680 meters (800 to 2,200 feet). Associated plant taxa include mosses, ferns, liverworts, pili grass, *Cuphea carthagenensis* (tarweed), and *Pilea peploides* (NCN) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Lysimachia filifolia*.

Historically, *Lysimachia filifolia* was known only from the upper portion of Olokele Valley on Kauai (HHP 1994). This species is now known from two other areas: the slopes of Waiahole Valley in the Koolau Mountains of Oahu, and the "blue hole" area of Waialeale, Kauai (HHP 1994; NTBG 1994; S. Perlman, personal communication 1994; K. Wood, personal communication 1994). The Oahu population contains about 150 to 200 individuals (CPC 1989, HHP 1994, NTBG 1994) and the Waialeale population contains an estimated 20 to 75 plants (S. Perlman, personal communication 1994). All populations of this species are located on State land.

e. Reasons for Decline and Current Threats

The major threat to *Lysimachia filifolia* is competition with alien plant taxa. Individuals of this species on Kauai are

damaged and destroyed by natural rock slides in their habitat, which is near the bottom of steep cliffs. *Hydrocotyle sibthorpioides* (marsh pennywort), tarweed, and thimbleberry, although not invasive weeds, are present in this near-pristine area of Waialeale and may degrade the native ecosystem. At least one feral pig has made its way into this area, indicating that this disruptive animal is a potential threat. Individuals of *Lysimachia filifolia* on Oahu are vulnerable to rock slides and compete for space with alien plants such as marsh pennywort, tarweed, *Ageratina riparia* (Hamakua pamakani), and *Schefflera actinophylla* (octopus tree). Because only one population of *Lysimachia filifolia* occurs on each of only two islands, the species is threatened by stochastic extinction. Hurricane Iniki caused at least some damage to the Waialeale population (USFWS 1994a).

f. Conservation Measures

Lysimachia filifolia has been successfully propagated and grown *ex situ* by Lyon Arboretum and NTBG. Present holdings at Lyon Arboretum consist of five plants in the greenhouse (C. Lamoureux, personal communication 1995). NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Lysimachia filifolia* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral pigs and alien plant taxa. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

17. ***Melicope haupuensis*** - RP# 5

a. Description and Taxonomy

No line drawing is available for *Melicope haupuensis*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

In 1927 MacDaniels collected a plant specimen on Kauai which St. John (1944) later named *Pelea haupuensis*. The specific epithet refers to the type locality, Haupu, the only known site for this plant until it was discovered in Waimea Canyon in 1989. Thomas G. Hartley and Benjamin C. Stone (1989, Stone et al. 1990, Wagner et al. 1990) synonymized the genus *Pelea* with *Melicope*, resulting in the current name for this taxon: *Melicope haupuensis*.

Melicope haupuensis, a member of the citrus family (Rutaceae), is a tree about 8 meters (26 feet) tall. The oval leaves, 5 to 13 centimeters (2 to 5.1 inches) long and 28 to 56 millimeters (1.1 to 2.2 inches) wide, are oppositely arranged. Flowers grow in clusters of five to seven on stalks usually 2 to 7 millimeters (0.1 to 2.8 inches) long, each flower on a stalk 1 to 3 millimeters (0.04 to 0.12 inches) long. Only female flowers are known. The flowers are about 3.5 millimeters (0.14 inches) long, dotted with oil glands, and covered with a dense mat of hairs. Fruits are distinct follicles (a dry fruit that splits open lengthwise), 9 to 11 millimeters (0.35 to 0.43 inches) long, with a hairless exocarp and endocarp (outermost and innermost layers of the fruit wall, respectively). Unlike other taxa of this genus on Kauai, the exocarp and endocarp are hairless and the sepals are covered with dense hairs (St. John 1944, Stone 1969, Stone et al. 1990).

b. Life History

Little is known about the life history of *Melicope haupuensis*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

These plants grow on moist talus slopes in ohia-dominated lowland mesic forests with such associated taxa as aalii and hame, at elevations between 375 and 820 meters (1,230 and 2,690 feet) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Melicope haupuensis*.

For 62 years, *Melicope haupuensis* was known only from the type locality on the north side of Haupu Ridge on Kauai (HHP 1994). This population is now gone. In 1989, two plants were discovered within 1.6 kilometers (1 mile) of each other along the banks of Koaie Stream on State-owned land in Waimea Canyon (HHP 1994; NTBG 1994; S. Perlman, personal communication 1995).

e. Reasons for Decline and Current Threats

Habitat degradation by feral goats and competition with invasive alien plant taxa such as lantana and yellow foxtail threaten *Melicope haupuensis*. A potential threat to members of this genus is their known susceptibility to black twig borer. The existence of only two known trees of this species constitutes a threat of stochastic extinction, over-collecting, and/or reduced reproductive vigor (USFWS 1994a).

f. Conservation Measures

No specific conservation measures are being conducted for *Melicope haupuensis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

18. ***Melicope knudsenii*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Melicope knudsenii*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Knudsen sent a plant specimen he found at Waimea to Hillebrand, who named it *Pelea knudsenii* in honor of its collector (Hillebrand 1888). In an action that was not supported by other taxonomists, Emmanuel Drake del Castillo (1890) transferred several species from the genus *Pelea* to the genus *Evodia*. Hartley and Stone (1989) synonymized the genus *Pelea* with *Melicope*, resulting in the combination *M. knudsenii*. Other names now included in *M. knudsenii* are *Pelea multiflora* (Rock 1911), *P. knudsenii* var. *multiflora* (Rock 1918), and *P. tomentosa* (St. John 1944).

Melicope knudsenii, a member of the citrus family, is a tree usually 3 to 10 meters (10 to 33 feet) tall with smooth gray bark and yellowish brown to olive-brown hairs on the tips of the branches. Leaves are variable, ranging from oblong to elliptic, 9 to 25 centimeters (3.5 to 9.8 inches) long, and 4.5 to 10 centimeters (1.8 to 3.9 inches) wide. The lower surface of the leaves is uniformly covered with olive-brown hairs, but the upper surface is only sparsely hairy along the midrib. The densely hairy flowers are bisexual or may be unisexual. There are usually 20 to 200 flowers per cluster in the leaf axils. The sepals and petals are covered with silky gray hairs, and the sepals persist in fruit. The fruits are 18 to 30 millimeters (0.7 to 1.2 inches) wide and are comprised of distinct follicles, 8 to 14 millimeters (0.3 to 0.6 inches) long. The hairless exocarp is dotted with minute glands. The endocarp also lacks hairs. Seeds number one or two per carpel (ovule-bearing structure) and are about 5 to 6 millimeters (0.2 inches) long. The distinct carpels of the fruit, the hairless endocarp, the larger number of flowers per cluster, and the distribution of hairs on the underside of the leaves distinguish this species from *M. haupuensis* and other species of the genus (Degener et al. 1962a, 1962b; Hillebrand 1888; Rock 1913; Stone 1969; Stone et al. 1990).

b. Life History

Little is known about the life history of *Melicope knudsenii*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Melicope knudsenii grows on forested flats or talus slopes in lowland dry to mesic forests at an elevation of about 450 to 1,000 meters (1,500 to 3,300 feet). The Auwahi population on

Maui, however, grows on a substrate of aa lava in a remnant native forest, dominated by a continuous mat of *Pennisetum clandestinum* (Kikuyu grass). Plants associated with the Kauai populations include aalii, hame, ohia, and *Xylosma* (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Melicope knudsenii*.

Historically, *Melicope knudsenii* was known only from the southeast slope of Haleakala on Maui and from Olokele Canyon on Kauai (HHP 1994). This species remains in the Auwahi and Kanaio area of Maui (USFWS 1994a) on privately owned land, but its numbers have decreased considerably from being "very common" in 1920 to between 20 and 30 plants when it was last observed in 1983 (CPC 1990, HHP 1994). On Kauai, four populations, each consisting of one individual, remain on State land. Three populations are in the Koaie drainage area of Waimea Canyon (HHP 1994, USFWS 1994) and are distributed across a distance of 2.6 kilometers (1.6 miles), and there is also one individual in upper Kuia Valley (K. Wood, personal communication 1994). This species therefore totals between 24 and 34 individuals at present.

e. Reasons for Decline and Current Threats

Competition with alien plant taxa and habitat degradation by feral and domestic animals are the major threats to *Melicope knudsenii*. On Kauai, this species competes with lantana and is affected by feral goats and pigs. On Maui, *Melicope knudsenii* grows in an area currently grazed by domestic cattle, where a continuous mat of Kikuyu grass prevents seedlings from establishing. Although cattle are a threat to this population, they also reduce the density of Kikuyu grass, which appears to be an even greater threat (Robert Hobdy, DOFAW, personal communication 1995). Feral goats and feral pigs are also present

in the area of the Maui population, and axis deer, found on the south slope of Haleakala and increasing in numbers, are a potential threat. This species is potentially threatened by black twig borer. This species is also threatened by fire, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals (USFWS 1994a).

f. Conservation Measures

No specific conservation measures are being conducted for *Melicope knudsenii* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats and alien weed threats. Kanio NAR, on the island of Maui is a good potential reestablishment site for this taxon (B. Hobdy, personal communication 1995). Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

19. ***Melicope pallida*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Melicope pallida*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Hillebrand (1888) described *Pelea pallida* based upon a specimen he collected on Oahu. The specific epithet refers to the

plant's pale leaf veins and lower leaf surfaces. Drake del Castillo (1890) transferred the species to the genus *Evodia*, a combination not accepted by other taxonomists. Faurie described *P. leveillei* in 1912 based upon a specimen collected on Kauai (Stone 1969). Following the transfer of the genus *Pelea* to *Melicope* (Hartley and Stone 1989, Wagner et al. 1990), authors of the current treatment of the Hawaiian members of the genus (Stone et al. 1990) now consider *Evodia pallida*, *P. pallida* and *P. leveillei* to be synonyms of *Melicope pallida*.

Melicope pallida, a member of the citrus family, is a 6- to 10-meter (20- to 33-foot) tree with grayish white hairs and black, resinous new growth. The leaves, 6 to 21 centimeters (2.4 to 8.3 inches) long and 2.5 to 8 centimeters (1 to 3.1 inches) wide, are grouped in threes, with each leaf loosely folded. Fifteen to 35 pale yellowish-green flowers are also clustered in groups of 3 along a fuzzy white stalk up to 6 centimeters (2.4 inches) long. The petals are usually lance-shaped and measure 3.5 to 5 millimeters (0.1 to 0.2 inches) long. Fruits contain two shiny black seeds about 3.5 millimeters (0.1 inches) long in each of the usually four distinct carpels. This species differs from *Melicope haupuensis*, *M. knudsenii*, and other members of the genus by the following combination of characteristics: resinous new growth, leaves folded and in clusters of three, and fruits with separate carpels (Degener et al. 1960, Hillebrand 1888, St. John 1944, Stone et al. 1990, Wagner et al. 1990).

b. Life History

Little is known about the life history of *Melicope pallida*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Melicope pallida usually grows on steep rock faces in drier regions of lowland mesic forests at an elevation of 490 to 910 meters (1,600 to over 3,000 feet). Associated plant taxa include *Abutilon sandwicense* (NCN), *Alyxia oliviformis* (maile), *Dryopteris* sp., ohia, *Pipturus albidus* (mamaki), *Sapindus oahuensis* (lonomea), *Tetraplasandra* sp. (ohe), and *Xylosma hawaiiense* (mana) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Melicope pallida*.

Historically, *Melicope pallida* was known from the Waianae Mountains on Oahu, from the base of Mount Kaala and near Palikea within The Nature Conservancy of Hawaii's (TNCH) privately owned Honouliuli Preserve and from Hanapepe on Kauai (HHP 1994). The population near Palikea was last visited in 1960 (HHP 1994) and *Melicope pallida* is now considered extinct on Oahu (S. Perlman, personal communication 1995). *Melicope pallida* is currently known only from Kauai. Populations presently exist at Kalalau Valley Rim (100 individuals), Honopu Rim (20 individuals), Koaie Stream in Waimea Canyon (10 individuals), Limahuli Valley (one individual), Pohakuao Valley (20 individuals), and Awaawapuhi Valley (6 individuals) (HHP 1994; NTBG 1994; USFWS 1994a; S. Perlman, personal communication 1995).

e. Reasons for Decline and Current Threats

The major threats to *Melicope pallida* are habitat destruction by feral animals and competition with alien plant taxa. On Kauai, feral goats and feral pigs destroy habitat of *Melicope pallida*, and weeds such as daisy fleabane and prickly Florida blackberry compete with the species. Additional threats

to *Melicope pallida* are the black twig borer, fire and stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (USFWS 1994a).

f. Conservation Measures

NTBG presently has seeds in short-term storage but has not sucessfully propagated this taxon (D. Ragone, personal communication 1995). No specific conservation measures are being conducted for *Melicope pallida* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

20. ***Melicope quadrangularis*** - RP# 5

a. Description and Taxonomy

There is no line drawing available for *Melicope quadrangularis*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

St. John and Edward P. Hume described *Melicope quadrangularis*, based upon a specimen collected by Forbes on Kauai in 1909 (St. John 1944). The specific epithet, meaning "four-angled," describes the cube-shaped capsule. Hartley and Stone (1989) synonymized the genus *Pelea* with *Melicope*, resulting in the combination *M. quadrangularis*.

Melicope quadrangularis, a member of the citrus family, is a shrub or small tree. Young branches are generally covered with fine yellow fuzz but become hairless with age. The thin,

leathery, elliptical leaves, 9.5 to 16 centimeters (3.5 to 6 inches) long and 4.5 to 7.5 centimeters (2 to 3 inches) wide, are oppositely arranged. The upper leaf surface is hairless, and the lower surface is sparsely hairy, especially along the veins. Flowers are solitary or in clusters of two. The specific floral details are not known. The fruits are somewhat cube-shaped, flattened capsules, about 13 millimeters (0.5 inches) long and about 19 to 22 millimeters (0.8 inches) wide with a conspicuous central depression at the top of the fruit. The capsules are four-lobed and completely fused. The exocarp is sparsely hairy, and the endocarp is hairless. This species differs from others in the genus in having the following combination of characters: oppositely arranged leaves, only one or two flowers per cluster, cube-shaped capsules with fused lobes, and a deep central depression at the top of the fruit (St. John 1944, Stone 1969, Stone et al. 1990).

b. Life History

Little is known about the life history of *Melicope quadrangularis*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

The plants are growing in a diverse lowland forest that ranges from mesic to wet conditions with other plants, such as ohia, opuhe, uluhe, *Broussaisia arguta* (kanawao), *Cyrtandra pickeringii* (haiwale), other *Melicope* species (alani), *Metrosideros waialealae*, and abundant ferns and mosses (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Melicope quadrangularis*.

Melicope quadrangularis is known from the type locality in the Wahiawa Bog region of Kauai (HHP 1994, Stone et al. 1990). One adult plant and two seedlings were discovered in 1991 by Ken Wood of NTBG on an east-facing slope of Wahiawa Ridge at 850 meters (2,800 feet) on privately owned land. Subsequent exploration has resulted in the location of a total of 13 individuals of this species.

e. Reasons for Decline and Current Threats

The existence of only 13 known plants of this species causes the species to be threatened by over-collecting for scientific purposes, stochastic extinction, and/or reduced reproductive vigor. Strawberry guava and prickly Florida blackberry grow in the area and are potential threats (USFWS 1994a).

f. Conservation Measures

No specific conservation measures are being conducted for *Melicope quadrangularis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

21. *Munroidendron racemosum* - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Munroidendron racemosum*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Forbes collected specimens of a tree on Kauai in 1916 which he described the following year (1917b) as *Tetraplasandra racemosa*. The specific epithet describes the inflorescence, which Forbes considered a raceme. Sherff (1952) transferred the species to the new endemic, monotypic genus *Munroidendron*, named in honor of George C. Munro, who was apparently the first to recognize the plant as a new taxon. Sherff (1952b) also published two varieties, *Munroidendron racemosum* var. *forbesii* and *M. racemosum* var. *macdanielsii*. In the current treatment of the species, Porter P. Lowrey II (1990) recognizes no subspecific taxa.

Munroidendron racemosum, a member of the ginseng family (Araliaceae), is a tree up to about 7 meters (23 feet) in height with a straight gray trunk crowned with spreading branches. The leaves are 15 to 30 centimeters (6 to 12 inches) long and comprise five to nine oval or elliptical leaflets with clasping leaf stalks. Each leaflet is 8 to 17 centimeters (3.1 to 6.7 inches) long and usually 4 to 10 centimeters (1.6 to 3.9 inches) wide. About 250 pale yellow flowers are borne along a stout hanging stalk 25 to 60 centimeters (10 to 24 inches) long. Each flower has five or six lance-shaped petals 8 to 10 millimeters (0.3 to 0.4 inches) long emerging from a cup-shaped or ellipsoid calyx tube. Both the lower surface of the petals and the calyx tube are covered with whitish scaly hairs. The fruit is an egg-shaped drupe 8 to 12 millimeters (0.3 to 0.5 inches) long and nearly as wide, situated atop a flat, dark red disk (stylopodium). This species is the only member of a genus endemic to Hawaii. The

genus differs from other closely related Hawaiian genera of the family primarily in its distinct flower clusters and corolla (Forbes 1917b, Lamoureux 1982, Lowrey 1990, St. John 1981b, Sherff 1952b).

b. Life History

Some reproduction is occurring, with flowering and fruiting year-round. Self pollination is assumed to occur due to viable seed produced by isolated individuals. Pollinators have not been observed, but insect pollination is likely. Dispersal mechanisms are unknown (Lamoureux 1982).

c. Habitat Description

Most populations are found on steep exposed cliffs or on ridge slopes in coastal to lowland mesic forests, but a few populations are in mesic *Pandanus tectorius* (hala) forests, lantana-dominated shrubland, or *Eragrostis* grassland. Other associated plant taxa include common guava, kopiko, kukui, and lama (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Munroidendron racemosum*.

Historically, *Munroidendron racemosum* was known from scattered locations throughout the island of Kauai (HHP 1994). Fifteen populations are now found at elevations of 120 to 400 meters (390 to 1,310 feet) on private and State land in the following areas: along the Na Pali Coast within Na Pali Coast State Park and Hono O Na Pali NAR, in the Poomau and Koaie branches of Waimea Canyon, in the Haupu Range area, and on Nounou Mountain (HHP 1994, Lamoureux 1982). Although widely distributed, the largest of the populations contains fewer than 50 individuals,

with most populations numbering only 1 or 2 individuals. There are an estimated total of 200 or more individuals of this species (S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The major threat to *Munroidendron racemosum* is competition with alien plant species (kukui, ti, Chinaberry, common guava, firetree, koa haole, lantana, and *Triumfetta semitriloba* (Sacramento bur)). Feral goats degrade the habitat of *Munroidendron*, and cattle were formerly present in areas where the trees grow. Other threats include fire and predation of the fruit by rats. An introduced insect of the longhorned beetle family (Cerambycidae) killed a mature, cultivated tree and has the potential of affecting wild trees. Because each population of this species contains only one or a few trees, the total number of individuals is small, threatening the species through over-collecting for scientific or horticultural purposes, stochastic extinction, and/or reduced reproductive vigor (USFWS 1994a).

f. Conservation Measures

Munroidendron racemosum has been successfully propagated and grown *ex situ* by Lyon Arboretum, NTBG, and Waimea Arboretum. Present holdings at Lyon Arboretum consist of seed in the tissue culture lab and five plants on arboretum grounds (C. Lamoureux, personal communication 1995). NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995), and Waimea Arboretum has three plants (J. Llop, personal communication 1995).

The Kauai District DOFAW has outplanted about 400 individuals at Kauhao Ridge, and additional outplanting of this taxon is planned for an exclosure at Haeleele Ridge in Puu Ka Pele Forest Reserve (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for

Munroidendron except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

22. ***Nothocestrum peltatum*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Nothocestrum peltatum*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

First collected on Kauai before 1900, *Nothocestrum peltatum* was described by Carl J. F. Skottsberg in 1944, based on a specimen collected by Olof H. Selling in 1938. The specific epithet refers to the peltate leaves, attached to the stalk by the lower surface, inside the leaf margin rather than at its edge. St. John (1986) later described *N. inconcinnum*, but David E. Symon (1990), in the currently accepted treatment of the genus, regards that name as a synonym of *N. peltatum*.

Nothocestrum peltatum, a member of the nightshade family (Solanaceae), is a small tree up to 8 meters (26 feet) tall with ash-brown bark and woolly stems. The leathery leaves are usually peltate, measure 6 to 23 centimeters (2.4 to 9.1 inches) long and 3.5 to 7.5 centimeters (1.4 to 3 inches) wide, and vary in shape from oval or elliptic to oblong. The densely hairy flowers number up to 10 per cluster. The corolla is greenish yellow fading to yellow orange and 12 to 14 millimeters (0.5 to 0.6 inches) long. The orange berries are 13 to 14 millimeters (0.5 to 0.6 inches) long and contain numerous irregularly shaped seeds about 2.5

millimeters (0.1 inches) in diameter. The usually peltate leaves and shorter leaf stalks separate this species from others in the genus (St. John 1986, Selling 1947, Skottsberg 1944, Symon 1990).

b. Life History

Although plants of this species flower, they rarely set fruit; this could be the result of a loss of pollinators, reduced genetic variability, or self-incompatibility (USFWS 1994a). Little else is known about the life history of *Nothocestrum peltatum*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species generally grows in rich soil on steep slopes in montane mesic forests dominated by koa or a mixture of ohia and koa, with associates such as hame, uluhe, *Bobea brevipes* (ahakea lau lii), *Elaeocarpus bifidus* (kalia), and more common alani species (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Nothocestrum peltatum*.

Historically, *N. peltatum* was known from Kauai at Kumuwela, Kaholuamanu, and the region of Nualolo (HHP 1994). This species is now known from a total of seven populations on Kauai located near the Kalalau Lookout area, Kalalau Valley, Awaawapuhi and Makaha Valleys, Waimea Canyon, Nualolo, and Kawaiula (HHP 1994; NTBG 1994; USFWS 1994a; S. Perlman, personal communication 1995). There are a total of approximately 23 individuals (CPC 1989, 1990; USFWS 1994a; S. Perlman, personal communication 1995).

e. Reasons for Decline and Current Threats

Competition with alien plants and habitat degradation by introduced animals constitute the major threats to *Nothocestrum peltatum*. Introduced plants competing with this species include banana poka, daisy fleabane, lantana, prickly Florida blackberry, and *Passiflora edulis* (passion fruit). Animals disturbing the habitat of this species include feral goats, feral pigs, mule deer, and red jungle fowl. This species is also threatened by fire, over-collecting for scientific or horticultural purposes, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals (USFWS 1994a).

f. Conservation Measures

Nothocestrum peltatum has been successfully propagated by NTBG, and NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Nothocestrum peltatum* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats, feral pigs, mule deer, red jungle fowl and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

23. *Peucedanum sandwicense* - RP# 8

a. Description and Taxonomy

Appendix B contains a line drawing of *Peucedanum sandwicense*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Hillebrand (1888) described *Peucedanum sandwicense* based upon a specimen collected on Molokai and *P. kauaiense* based upon a specimen collected on Kauai. He also referred to an unnamed variety of *P. sandwicense* from Maui. Otto and Isa Degener (1960) later named the Maui plant *P. sandwicense* var. *hiroi*. In their current treatment, Lincoln Constance and James Affolter (1990) recognize only *P. sandwicense* for all populations of the genus in the Hawaiian Islands.

Peucedanum sandwicense, a member of the parsley family (Apiaceae), is a parsley-scented, sprawling herb usually 0.5 to 1 meters (20 to 40 inches) tall. Hollow stems arise from a short, vertical, perennial stem with several fleshy roots. The compound leaves are generally three-parted with stalkless leaflets, each egg- or lance-shaped and toothed. The larger terminal leaflet is usually one- to three-lobed and 7 to 13 centimeters (2.8 to 5.1 inches) long. The other leaflets have leaf stalks 4 to 20 inches (10 to 50 centimeters) long or are stalkless. Flowers are clustered in a compound umbel of 10 to 20 flowers. The round petals are white and bent inward at the tips. The flat, dry, oval fruits are 10 to 13 millimeters (0.4 to 0.5 inches) long and 5 to 8 millimeters (0.2 to 0.3 inches) wide, splitting in half to release a single flat seed. This species is the only member of the genus in the Hawaiian Islands, one of three genera of the family with taxa endemic to the island of Kauai. This species differs from the other Kauai members of the parsley family in having larger fruit and pinnately compound leaves with broad

leaflets (Constance and Affolter 1990, Degener and Constance 1959, Degener and Degener 1960, Hillebrand 1888).

b. Life History

Little is known about the life history of *Peucedanum sandwicense*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species grows in cliff habitats from sea level to above 900 meters (3,000 feet) and is associated with native species such as akoko, kawelu, lama, ohia, ahinahina, and alien species such as common guava and lantana (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Peucedanum sandwicense*.

Historically, *Peucedanum sandwicense* was known from three islands: Kalaupapa, Pauonuakea Kui, Waikolu, and Wailau Valley on Molokai; Wailuku and Waiehu on Maui; and various locations in the Waimea Canyon and Olokele regions of Kauai (HHP 1994, NTBG 1994). Discoveries in 1990 extended the known distribution of this species to the island of Oahu, where two populations totalling about 85 individuals exist in the Waianae Mountains on County and State land (J. Lau, in litt. 1991; USFWS 1994a). One population of 20 to 30 individuals is known from State-owned Keopuka Rock, an islet off the coast of Maui (HHP 1994; Hobdy 1982; USFWS 1994a). On Molokai, 3 populations totalling fewer than 30 individuals are found on private and State-owned land in Pelekunu Preserve, Kalaupapa National Historical Park, and Huelo, an islet off the coast of Molokai (HHP 1994; USFWS 1994a). The 10 Kauai

populations are distributed in Waimea Canyon and along the Na Pali Coast within 1.5 miles (2.4 kilometers) of the ocean (HHP 1994; USFWS 1994a). These populations are found within a 11- by 13-kilometer (7- by 8-mile) area on private and State land. The total number of plants in the 16 known populations of this species is estimated to be between 1,000 and 5,000 individuals (CPC 1992, USFWS 1994a).

e. Reasons for Decline and Current Threats

Competition with introduced plants and habitat degradation and browsing by feral goats are the major threats to *Peucedanum sandwicense*. Kauai populations are affected by alien plant species such as air plant, banana poka, common guava, daisy fleabane, firetree, introduced grasses and lantana, as well as by feral goats. The Hanakapiai population on Kauai is close enough to the trail that it is potentially affected by hikers and trail clearing. Oahu populations are threatened by alien plants such as Christmas berry, common guava, daisy fleabane, Hamakua pamakani, silk oak, and *Stachytarpheta*; feral goats; fire; and landslides. The Kalaupapa, Molokai, population of *P. sandwicense* competes with Christmas berry, common guava, and molasses grass and is also threatened by goats and deer. The Pelekunu, Molokai, population is threatened by common guava, Hamakua pamakani, *Ageratina adenophora* (Maui pamakani), and potentially by axis deer. Plants of this species on Huelo are vulnerable to natural rock slides. The population on Keopuka Rock is threatened by alien grasses, lantana, and sourbush (USFWS 1994a).

f. Conservation Measures

Peucedanum sandwicense has been successfully propagated and grown *ex situ* by NTBG and Waimea Arboretum. NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995), and Waimea Arboretum has 24 plants (J. Llop, personal

communication 1995). No additional conservation measures are being conducted for *Peucedanum sandwicense* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

24. ***Phyllostegia waimeae*** - RP# 5

a. Description and Taxonomy

No line drawing is available for *Phyllostegia waimeae*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Wawra collected a specimen of *Phyllostegia waimeae* on Kauai in 1870 while he was a member of the Austrian East Asiatic Exploring Expedition. In 1872 he described the species, naming it for Waimea Canyon where he collected it. St. John (1987c) recently published many species, varieties, and combinations in *Phyllostegia*, one or more of which may fit into this species (Wagner et al. 1990).

Phyllostegia waimeae, a nonaromatic member of the mint family (Lamiaceae), is a climbing perennial plant with hairy four-angled stems that are woody at the base. The oval leaves are 5 to 13 centimeters (2 to 5 inches) long, 2.5 to 6 centimeters (1 to 2.4 inches) wide, and have rounded, toothed margins. They are wrinkled and sparsely dotted with oil glands. Flowers grow in groups of six along an unbranched leafy stalk usually 10 to 15 centimeters (3.9 to 5.9 inches) long. The bracts below each flower stalk are broad and partially overlap the flowers. The calyx resembles an inverted cone with broad lobes. The corolla, 8

to 12 millimeters (0.3 to 0.5 inches) long, is pinkish or may be white. The fruits, probably nutlets, have not been observed. Characteristics that distinguish this species from others in the genus are the nearly stalkless bracts that partially overlap and cover the flowers and relatively fewer oil glands on the leaves (Hillebrand 1888, Sherff 1935b, Wagner et al. 1990, Wawra 1872).

b. Life History

Little is known about the life history of *Phyllostegia waimeae*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species typically grows on shallow to deep, well-drained soils in clearings or along the banks of streams of diverse montane mesic to wet forests at elevations from 915 to 1,100 meters (3,000 to 3,600 feet). Associated taxa include ohia and *Pritchardia minor* (loulu) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Phyllostegia waimeae*.

Historically, *Phyllostegia waimeae* was known from Kaholuamanu and Kaaha on Kauai (HHP 1994). Most recently, this species is known from State land on Kauai in the Halemanu and Waimea Canyon areas, although the Halemanu population has not been seen for almost 40 years (HHP 1994). The Waimea Canyon population consists of a single plant, which has not been observed since 1969 (USFWS 1994a).

e. Reasons for Decline and Current Threats

Habitat destruction by feral goats, erosion, and competition with introduced grasses are the major threats to *Phyllostegia waimeae*. The species is also threatened by over-collecting for scientific purposes, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals (USFWS 1994a).

f. Conservation Measures

No specific conservation measures are being conducted for *Phyllostegia waimeae* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, this taxon first needs to be relocated. Propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

25. ***Poa mannii*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Poa mannii*.

The information in this section is taken directly from the listing action covering *Poa mannii* (USFWS 1994b).

Poa mannii was first collected by Horace Mann, Jr., and William Tufts Brigham in 1864 or 1865 in Waimea Canyon on the

island of Kauai. The name *Poa mannii* was published in Seemann's Journal of Botany in 1869 without a diagnosis and was attributed to William Munro. The specific epithet was selected to honor one of the original collectors. Subsequently, the species was validly published by Hillebrand (1888) in his flora.

Poa mannii of the grass family (Poaceae) is a perennial grass with short rhizomes (underground stems) and erect, tufted culms (bunched stems) 50 to 75 centimeters (20 to 30 inches) tall. The leaf sheath completely surrounds the leaf, and the ligule (appendage at the junction of the leaf blade and sheath) completely encircles the stem, is about 0.5 millimeters (0.02 inches) long, and has a tooth about 2 to 4 millimeters (0.08 to 0.2 inches) long and a fringed margin. The leaf blade is up to 15 centimeters (6 inches) long and 2 to 4 millimeters (0.08 to 0.2 inches) wide, and has a rough upper surface and a hairless lower surface. The panicles (branched flower clusters) are usually less than 5 centimeters (2 inches) long and have primary branches 5 to 20 millimeters (0.2 to 0.8 inches) long. The 4 to 7 millimeters (0.2 to 0.3 inches) long, flattened spikelets (ultimate flower clusters) are pale greenish or yellowish brown and usually are comprised of four or five flowers. The glumes (small pair of bracts at the base of each spikelet) are about 3 millimeters (0.1 inches) long. The lemma (outer bract at the base of a floret) is 3 to 4 millimeters (0.1 to 0.2 inches) long and has cobwebby hairs at its base. The palea (inner bract at the base of a floret) is about 3 to 3.5 millimeters (0.1 inches) long and has a sharp, longitudinal ridge. The reddish brown grain-like fruit is elliptical to spindle-shaped and about 1.5 millimeters (0.06 inches) long. All three native species of *Poa* in the Hawaiian Islands are endemic to the island of Kauai. *Poa mannii* is distinguished from both *Poa siphonoglossa* and *Poa sandvicensis* by its fringed ligule and from *Poa sandvicensis* by its shorter panicle branches (O'Connor 1990).

b. Life History

Little is known about the life history of *Poa mannii*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species typically grows on cliffs and rock faces at elevations between 460 and 1,150 meters (1,510 and 3,770 feet) in lowland and montane mesic forests. Associated species include akoko, *Exocarpos luteolus* (heau), *Labordia helleri* (kamakahala), and *Nototrichium* sp. in Kalalau Valley; *Cyrtandra wawrae* (haiwale) in Makaha Valley; koa, mahoe, and hame in Koaie Valley; and *Bidens cosmoides* (poola nui), *Carex meyenii*, aalii, and *Schiedea amplexicaulis* in Waialae Valley.

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Poa mannii*.

Poa mannii is found only on the northwestern and west-central portions of the island of Kauai. The five known populations extend over a distance of about 8.5 by 10.5 kilometers (5.3 by 6.5 miles) and are found in Kalalau, Makaha, Koaie, Waialae and Kuia Valleys, all on State lands (USFWS 1993; K. Wood, personal communication 1994). The species was formerly found in Olokele Gulch (O'Connor 1990). Approximately 135 individuals have been observed in the extant populations.

e. Reasons for Decline and Current Threats

Poa mannii survives only in very steep areas that are inaccessible to goats, suggesting that goat predation may have

eliminated this species from more accessible locations, as is the case for other rare plants from northwestern Kauai. Threats to *Poa mannii* include habitat damage, trampling, and browsing by feral goats, and competition with invasive alien plants. Daisy fleabane has invaded Kalalau, Koaie and Waialae Valleys, three of the four areas where *Poa mannii* occurs. Lantana threatens all known populations, and prickly Florida blackberry threatens the Kalalau and Waialae Valley populations. *Poa mannii* is also threatened by landslides in the steep habitat, fire, and reduced reproductive vigor and/or extinction from stochastic events due to the small number of existing populations and individuals (USFWS 1993).

f. Conservation Measures

NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). The Kauai District DOFAW is planning a plant sanctuary project in the Kalalau Rim area which will include fencing and other management (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Poa mannii* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats and invasive alien plants. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

26. *Poa sandvicensis* - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Poa sandvicensis*.

The information in this section is taken directly from the listing package covering six of the Kauai cluster taxa (USFWS 1992a).

Probably the earliest collection of *Poa sandvicensis* was that of Horace Mann and William Brigham from "above Waimea" in 1864 or 1865 (Hillebrand 1888). This species was first described as *Festuca sandvicensis* by H.W. Reichardt in 1878, based on collections from Halemanu. Ten years later, William Hillebrand (1888) described Mann and Brigham's specimen, along with other material, as *Poa longeradiata*. In 1922, Albert Hitchcock combined these and additional collections under the name *Poa sandvicensis*.

Poa sandvicensis is a perennial grass (family Poaceae) with densely tufted, mostly erect culms 0.3 to 1 meters (1 to 3.3 feet) tall. The short rhizomes form a hardened base for the solid, slightly flattened culms. The leaf sheaths are closed and fused, but may split with age. The toothed ligule completely surrounds the culm and has a hard tooth extending upward from the mouth of the sheath. The leaf blades are 10 to 20 centimeters (4 to 8 inches) long, and up to 6 millimeters (0.2 inches) wide. The flowers occur in complex clusters with lower panicle (primary) branches up to 10 centimeters (4 inches) long. The lemmas have only a sparse basal tuft of cobwebby hairs. The fruits are golden brown to reddish brown, oval grains. *Poa sandvicensis* is distinguished from closely related species by its shorter rhizomes, shorter culms which do not become rush-like with age, closed and fused sheaths, relatively even-edged ligules, and longer panicle branches (O'Conner 1990).

b. Life History

Little is known about the life history of *Poa sandvicensis*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Poa sandvicensis grows on wet, shaded, gentle to usually steep slopes, ridges, and rock ledges in semi-open to closed, mesic to wet, diverse montane forest dominated by ohia, at an elevation of 1,035 to 1,250 meters (3,400 to 4,100 feet). Associated native species include koa, kopiko, manono, naupaka kuahiwi, pilo, *Cheirodendron* (olapa), and *Syzygium sandwicensis* (ohia ha). Associated alien species include prickly Florida blackberry, banana poka, ginger, and daisy fleabane (USFWS 1992a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Poa sandvicensis*.

All collections and confirmed sightings of this species are from six areas on the island of Kauai: the rim of Kalalau Valley in Na Pali Coast State Park; Halemanu and Kumuwela Ridge/Kauaikinana drainage in Kokee State Park; Awaawapuhi Trail in Na Pali-Kona Forest Reserve; Kohua Ridge/Mohihi drainage in both the Forest Reserve and Alakai Wilderness Preserve; and Kaholuamanu on privately owned land (HHP 1994, NTBG 1994, Hitchcock 1922, USFWS 1992a). *Poa sandvicensis* is known to be extant at the Kalalau, Awaawapuhi, Kumuwela/ Kauaikinana, and Kohua/Mohihi localities and totals fewer than 1,000 individuals; it is currently known only from State-owned land. Hillebrand's (1888) questionable reference to a Maui locality is most likely an error.

e. Reasons for Decline and Current Threats

The greatest immediate threat to the survival of *Poa sandvicensis* is competition from alien plants. Daisy fleabane is the primary alien plant threat to the Kalalau population of *P. sandvicensis*. Prickly Florida blackberry threatens the Awaawapuhi, Kalalau, and Kohua Ridge populations. Banana poka and ginger also threaten the Awaawapuhi population. Erosion caused by pigs currently threatens the Kohua Ridge population, and both pigs and goats threaten the Kalalau population. State forest reserve trail maintenance threatens the trailside Awaawapuhi population. While *Poa sandvicensis* is known from four populations spread over a distance of about 8 by 3 kilometers (5 by 2 miles), 80 percent of the plants are concentrated at one major site. This species is therefore subject to an increased potential for extinction resulting from stochastic events, because a single event could extirpate 80 percent of the known individuals. The small population size with its limited gene pool also constitutes a serious potential threat (USFWS 1992a).

f. Conservation Measures

NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Poa sandvicensis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

27. ***Poa siphonoglossa*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Poa siphonoglossa*.

The information in this section is taken directly from the listing package covering six of the Kauai cluster taxa (USFWS 1992a).

Poa siphonoglossa was first collected in 1910 by Abbe Urbain Faurie, and was described 2 years later by E. Hackel (1912). According to Hitchcock (1922), one of the two specimens on which Hackel based his description was actually *Poa mannii*. While the localities for Faurie's two specimens are confused, the specimen that Hitchcock designated as the type was most likely collected at an elevation of about 1,000 meters (3,000 feet) above Waimea town, possibly near Kaholuamanu (Hitchcock 1922).

Poa siphonoglossa differs from *P. sandvicensis* principally by its longer culms, lack of a prominent tooth on the ligule, and shorter panicle branches. *Poa siphonoglossa* has extensive tufted and flattened culms that cascade from banks in masses up to 4 meters (13 feet) long. The naked, rush-like older culms have bladeless sheaths; the sheaths do not split with age. The ligule has no hard tooth. The flat, loosely packed leaf blades are usually less than 10 centimeters (4 inches) long and 3 millimeters (0.1 inches) wide. The primary panicle branches are about 3 centimeters (0.1 inches) long. The lemmas lack cobwebby hairs. The fruits are reddish brown and oval. Short rhizomes, long culms, closed and fused sheaths, and lack of a tooth on the ligule separate *P. siphonoglossa* from *P. mannii* and other closely related species (O'Conner 1990).

b. Life History

Little is known about the life history of *Poa siphonoglossa*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Poa siphonoglossa typically grows on shady banks near ridge crests in predominantly native mesic ohia forest between about 1,000 to 1,200 meters (3,300 and 3,900 feet) in elevation. Associated species include the natives aalii, manono, alani, and *Vaccinium* (ohelo), pukiawe, *Carex meyenii*, *Carex wahuensis*, and *Wilkesia gymnoxiphium* (iliau) and the alien prickly Florida blackberry (USFWS 1992a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Poa siphonoglossa*.

All collections and confirmed sightings of *Poa siphonoglossa* are from five sites on the island of Kauai: Kohua Ridge in Na Pali-Kona Forest Reserve, near Kaholuamanu on privately owned land, Kaulaula Valley in Puu Ka Pele Forest Reserve, Kuia Valley and Kalalau (USFWS 1992a; HHP 1994; S. Perlman, personal communication 1994; K. Wood, personal communication 1994). *Poa siphonoglossa* is still extant at Kohua Ridge (30 individuals), Kuia Valley (10 individuals) and Kalalau (2 individuals), on State-owned land (USFWS 1992a; S. Perlman, personal communication 1994; K. Wood, personal communication 1994).

e. Reasons for Decline and Current Threats

The primary threat to the survival of *Poa siphonoglossa* is habitat degradation and/or predation by pigs and deer. The Kohua Ridge population of this species may be at risk due to erosion caused by pigs, and the presence of both pigs and deer may threaten the Kaulaula population. The alien prickly Florida blackberry invading Kohua Ridge constitutes a probable threat to that population. A limited gene pool and potential for one disturbance event to destroy the majority of known individuals are serious threats to this species (USFWS 1992a).

f. Conservation Measures

NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). The Kauai District DOFAW is planning a plant sanctuary project in the Kalalau Rim area which will include fencing and other management (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Poa siphonoglossa* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats, feral pigs and invasive alien plants. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

28. *Pteralyxia kauaiensis* - RP# 8

a. Description and Taxonomy

Appendix B contains a line drawing of *Pteralyxia kauaiensis*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Based upon a specimen collected by Duvel and Harold L. Lyon in 1925, Edward L. Caum (1933) described *Pteralyxia kauaiensis*, named for the island where it grows. St. John (1981a) later published *P. elliptica*, but the authors of the current treatment of the genus (Wagner et al. 1990) regard that name to be synonymous with *P. kauaiensis*.

Pteralyxia kauaiensis, a member of the dogbane family (Apocynaceae), is a tree 3 to 8 meters (10 to 26 feet) tall. The leaves are dark green and shiny on the upper surfaces but pale and dull on the lower surfaces. They are generally egg-shaped and usually 11 to 22 centimeters (4.3 to 8.7 inches) long and 40 to 65 millimeters (1.6 to 2.6 inches) wide. The pale yellow flowers are trumpet-shaped, 8 to 12 millimeters (0.3 to 0.5 inches) long, with each of the five lobes 3 to 4 millimeters (0.1 to 0.2 inches) long. The paired fruits, of which usually only one matures, are drupe-like, bright red, and fleshy. The woody endocarp that encloses the single seed has two prominent central wings and two reduced lateral wings. This species differs from the only other taxa in this endemic Hawaiian genus in having reduced lateral wings on the seed (Caum 1933; Degener 1933, 1936; Lamb 1981; St. John 1981a; Wagner et al. 1990).

b. Life History

Little is known about the life history of *Pteralyxia kauaiensis*. Flowering cycles, pollination vectors, seed dispersal

agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This taxon grows on slopes and ridges in diverse mesic to sometimes wet forests at an elevation of 250 to 610 meters (810 to 1,990 feet) (Wagner et al. 1990). Associated plant taxa include hame, lama, lantana, ohia, and *Pouteria sandwicensis* (alaa) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Pteralyxia kauaiensis*.

Historically, *Pteralyxia kauaiensis* was known from the Wahiawa Mountains in the southern portion of Kauai (HHP 1994). This species is now known from the following scattered locations on private and State land on Kauai at elevations between 250 and 610 meters (820 and 2,000 feet) (Wagner et al. 1990): Mahanaloa-Kuia Valley in Kuia NAR, Haeleele Valley, Na Pali Coast State Park, Limahuli Valley, the Koaie branch of Waimea Canyon, Haupu Range, Wailua River, and Moloaa Forest Reserve (HHP 1994, NTBG 1994, USFWS 1994a). There is an undocumented sighting of 1 individual at Makaleha, above the town of Kapaa (USFWS 1994), making a total of 9 known populations, with an estimated 500 to 1000 individuals (S. Perlman, personal communication 1994).

e. Reasons for Decline and Current Threats

The major threats to *Pteralyxia kauaiensis* are habitat destruction by feral animals and competition with introduced plants. Animals affecting the survival of this species include feral goats, feral pigs, and possibly rats, which may eat the fruits. Fire and over-collecting for scientific purposes could

threaten some populations. Introduced plants competing with this species include common guava, daisy fleabane, kukui, lantana, strawberry guava, and ti (USFWS 1994a).

f. Conservation Measures

NTBG presently has seeds in short-term storage and this taxon has been successfully propagated (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Pteralyxia kauaiensis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

29. ***Remya kauaiensis*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Remya kauaiensis*.

The information in this section is taken directly from the listing package covering three species of *Remya* (USFWS 1991b).

Remya, a genus in the aster family (Asteraceae), comprises three species and is endemic to the Hawaiian Islands. The genus was described in 1876 by George Bentham in Bentham and Hooker's *Genera plantarum* (Bentham 1876), and was named in honor of Ezechiel Jules Remy, a French naturalist and ethnobotanist who visited Hawaii twice during an extended trip around the world from 1851 to 1863.

The members of this genus are small perennial shrubs, about 90 centimeters (3 feet) tall, with many slender, sprawling or scandent to weakly erect branches. The branches are glabrous in

Remya montgomeryi, but covered with a fine tan fuzz near their tips in the other two species. The leaves are narrow, up to about 15 centimeters (6 inches) long, and are bunched at the ends of the branches. The leaves are coarsely toothed along the edges, and are green on the upper surface. The lower surface is green in *R. montgomeryi*, while in the other two species it is covered with a dense mat of fine white hairs. The flowers are small, about 0.7 centimeters (0.3 inches) in diameter, dark yellow, and densely clustered at the ends of their stems (Wagner et al. 1990).

b. Life History

Seedlings of this taxon have not been observed. Flowers have been observed in April, May, June and August and are probably insect-pollinated. Seeds are probably wind or water-dispersed. *Remya kauaiensis* may be self-incompatible (Herbst 1988).

c. Habitat Description

Remya kauaiensis grows chiefly on steep, north or northeast-facing slopes between 850 to 1,250 meters (2,800 to 4,100 feet) in elevation. *R. kauaiensis* is found primarily in mesic forests, or the remnants of such forests. One known population of *Remya kauaiensis* grow on the steep cliffs below the rim of Kalalau Valley, which, although at the edge of a mesic forest, receives considerably more moisture than do the other populations of the genus (USFWS 1991b). Other populations are scattered throughout the drier ridges of Northwest Kauai and in Waimea Canyon (K. Wood, personal communication 1994).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Remya kauaiensis*.

Remya kauaiensis was first collected prior to 1871 by Valdemar Knudsen at "Waimea" on Kauai. Knudsen sent the specimen to William Hillebrand, a Honolulu physician, who described it as a new species. It was next collected more than 80 years later, in 1952, by Otto Degener in Kokee State Park, Kauai. The species was considered extinct until 1983 when it was rediscovered by Galen Kawakami, a forester on Kauai who discovered two small populations also in the Kokee area. Five additional small populations have been discovered in the Kokee area and just below the rim of Kalalau Valley distributed within a total area of less than 1 hectare (2 acres). Other populations have been found in the Na Pali Kona Forest Reserve at Koaie, Mohihi, Kalalau, Makaha, Nualolo, Kawaiula, Kuia, Honopu, Awaawapuhi, Kopakaka and Kauhao. These populations range in size from fewer than 10 to fewer than 100 plants each, with an estimated total of fewer than 200 individuals (NTBG 1994; USFWS 1991b; S. Perlman, personal communication 1995).

e. Reasons for Decline and Current Threats

The primary threats to *Remya kauaiensis* include predation and habitat degradation by feral ungulates (goats, pigs and deer) and competition from alien plant species. Other threats include erosion and fire (USFWS 1991b).

f. Conservation Measures

NTBG presently has seeds in short-term storage but have not been able to successfully propagate this taxon (D. Ragone, personal communication 1995). The Kauai District DOFAW is planning a fencing project to protect about 15 individuals of this taxon in Kokee State Park (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Remya kauaiensis* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

30. ***Remya montgomeryi*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Remya montgomeryi*.

The information in this section is taken directly from the listing package covering three species of *Remya* (USFWS 1991b).

Remya, a genus in the aster family (Asteraceae), comprises three species and is endemic to the Hawaiian Islands. The genus was described in 1876 by George Bentham in Bentham and Hooker's *Genera plantarum* (Bentham 1876), and was named in honor of Ezechiel Jules Remy, a French naturalist and ethnobotanist who visited Hawaii twice during an extended trip around the world from 1851 to 1863.

Remya montgomeryi was discovered in 1985 by Steven Montgomery on the sheer, virtually inaccessible cliffs below the upper rim of Kalalau Valley, Kauai, and presently is known only from that population (Wagner et al. 1990). It was described as a new species in 1987 (Wagner and Herbst 1987).

The members of this genus are small perennial shrubs, about 90 centimeters (3 feet) tall, with many slender, sprawling or scandent to weakly erect branches. The branches are glabrous in *Remya montgomeryi*, but covered with a fine tan fuzz near their tips in the other two species. The leaves are narrow, up to about 15 centimeters (6 inches) long, and are bunched at the ends of the branches. The leaves are coarsely toothed along the edges, and are green on the upper surface. The lower surface is green in *R. montgomeryi*, while in the other two species it is covered with a dense mat of fine white hairs. The flowers are small, about 0.7

centimeters (0.3 inches) in diameter, dark yellow, and densely clustered at the ends of their stems (Wagner et al. 1990).

b. Life History

Seedlings of this taxon have not been observed. Flowers have been observed in April, May, June and August and are probably insect-pollinated. Seeds are probably wind or water-dispersed. *Remya montgomeryi* may be self-incompatible (Herbst 1988).

c. Habitat Description

Remya grows chiefly on steep, north or northeast-facing slopes between 850 to 1,250 meters (2,800 to 4,100 feet) in elevation. One population of *Remya montgomeryi* grows on the steep cliffs below the rim of Kalalau Valley, which, although at the edge of a mesic forest, receives considerably more moisture than do the other populations of the genus (USFWS 1991b).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Remya montgomeryi*.

Because of the sprawling habit of the members of this genus, and the often dense growth of the surrounding vegetation, it is difficult to determine the exact number of individuals in a population. *Remya montgomeryi* is known from two populations on Kauai. One population, on the rim of Kalalau Valley, consists of approximately 50 to 70 plants (S. Perlman, personal communication 1994). A population at upper Koaie Canyon has five plants (S. Perlman, personal communication 1994; K. Wood, personal communication 1994).

e. Reasons for Decline and Current Threats

The primary threats to *Remya montgomeryi* are predation and habitat degradation by feral ungulates (goats, pigs and deer) and competition from alien plant species. Other threats include erosion, fire and stochastic extinction by virtue of the extremely small size of the populations coupled with a limited distribution. The limited gene pool may depress reproductive vigor, or a single environmental disturbance could destroy a significant percentage of the known individuals (USFWS 1991b).

f. Conservation Measures

NTBG presently has seeds in short-term storage but has been unable to successfully propagate this taxon (D. Ragone, personal communication 1995). The Kauai District DOFAW is planning a plant sanctuary project in the Kalalau Rim area which will include fencing and other management (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Remya montgomeryi* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral ungulates and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

31. ***Schiedea apokremnos*** - RP# 8

a. Description and Taxonomy

Appendix B contains a line drawing of *Schiedea apokremnos*.

The information in this section is taken directly from the listing package covering two Na Pali Coast Plants (USFWS 1991a).

Schiedea apokremnos was first collected in the early 1900s by J.M. Lydgate from an unrecorded locality on Kauai. Harold St. John made the next collection at Nualolo Kai on the Na Pali coast in 1965. Five years later, he described the taxon as a new species (St. John 1970), naming it for the plant's habitat of steep cliffs.

Schiedea apokremnos is a low, branching shrub 20 to 50 centimeters (8 to 20 inches) tall, of the pink family (Caryophyllaceae). The leaves are oppositely arranged, oblong, somewhat fleshy and glabrous, about 3 to 5 centimeters (1 to 2 inches) long and 0.6 to 1.2 centimeters (0.2 to 0.5 inches) wide. The flowers lack petals and are in clusters with green and often purple-tinged bracts and sepals; the sepals are about 2 to 3 millimeters (0.1 inches) long. The round to kidney-shaped seeds are produced in capsules. *Schiedea apokremnos* is distinguished from related species by shorter sepals, nectaries, and capsules (Wagner et al. 1990).

b. Life History

Little is known about the life history of *Schiedea apokremnos*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Schiedea apokremnos grows in the crevices of near-vertical coastal cliff faces, occupying cliffs and rock outcrops from 60 to 330 meters (200 to 1,100 feet) in elevation. Sparse dry coastal shrub vegetation with the natives ahinahina and akoko, and the alien sourbush is typical of the lower elevation sites of *S. apokremnos*. The upper elevation sites are dominated by the introduced koa haole, with natives dwarf iliau, nehe, and *Lobelia niihauensis* (USFWS 1991a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Schiedea apokremnos*.

Schiedea apokremnos has been collected from Nualolo Kai on the Na Pali coast, Kaaweiki Ridge and three areas along a 10.5 kilometers (6.5 miles) long section of the Na Pali coast: Milolii Valley, Kalalau Beach, between Kaaalahina and Manono ridges and as far north as Pohakuao Valley. A new population with more than 500 individuals was discovered on Haeleele ridge in 1992. The species is probably extant at all locations except Nualolo Kai, although the Kalalau and Milolii populations have not been revisited for over 6 years (USFWS 1991a). A total of about 600 plants has been seen, with only the Kaaalahina-Manono and Haeleele ridge populations numbering more than 5 individuals (Corn 1984; HHP 1994; NTBG 1994; USFWS 1991a). More plants could exist in similar, inaccessible habitat (USFWS 1991a). *Schiedea apokremnos* is known strictly from State-owned land. The Kaaweiki population is in Puu Ka Pele Forest Reserve and the Haeleele ridge population is in Polihale State Park, while all others are in Na Pali Coast State Park.

e. Reasons for Decline and Current Threats

The restriction of this species to inaccessible cliffs suggests that goat predation may have eliminated them from more accessible locations. The greatest current threat to the survival of *Schiedea apokremnos* is still predation and habitat degradation by feral goats. Alien plants (Koa haole and *Hyptis pectinata* (comb hyptis)) are a threat to the Kaaweiki population of *S. apokremnos*. However, most of the other populations of *S. apokremnos*, confined to sparsely vegetated cliff crevices, are apparently not threatened by alien plants. The small size of most populations and a restricted distribution are serious potential threats to this species. The limited gene pool may depress reproductive vigor, or a single environmental disturbance could destroy a significant percentage of the extant individuals. Landslides and fire pose additional potential threats. Some *S. apokremnos* individuals are functionally female and must be cross-pollinated to set seed. This reproductive strategy may threaten populations with few individuals (USFWS 1991a).

f. Conservation Measures

Schiedea apokremnos has been successfully propagated and grown *ex situ* by NTBG. NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Schiedea apokremnos* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

32. *Schiedea spergulina* var. *leiopoda* - RP# 6

a. Description and Taxonomy

No line drawing is available for *Schiedea spergulina* var. *leiopoda*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

Gray (1854) described *Schiedea spergulina* based upon a specimen collected in 1840 on Kauai during the United States Exploring Expedition. The specific epithet means "resembling *Spergula*," another genus in the same plant family. Two varieties of *Schiedea spergulina* are recognized in the current treatment of the genus (Wagner et al. 1990): the typical variety, which includes var. *degeneriana*, named by Sherff (1956); and var. *leiopoda* (Sherff 1944), which includes var. *major*, also named by Sherff (1944).

Schiedea spergulina, a member of the pink family (Caryophyllaceae), is a 30 to 60 centimeter (1 to 2 foot) tall subshrub. The opposite leaves are very narrow, usually 30 to 65 millimeters (1.2 to 2.6 inches) long and about 1.4 millimeters (0.04 inches) wide, one-veined, and attached directly to the stem. The flowers are unisexual, with male and female flowers on different plants. Flowers occur in compact clusters of three. The sepals usually number five and are green and purple-tinged, 2 to 3.3 millimeters (0.08 to 0.13 inches) long. The capsular fruits are about 2 to 3 millimeters (0.08 to 0.12 inches) long and contain nearly smooth, kidney-shaped seeds. Of the 22 species in this endemic genus, only two other species have smooth seeds. *Schiedea spergulina* differs from those two in having very compact flower clusters. The two weakly defined varieties differ primarily in the degree of hairiness (Heller 1897; Hillebrand 1888; Sherff 1944, 1945; Wagner et al. 1990).

b. Life History

Little is known about the life history of *Schiedea spergulina* var. *leipoda*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This taxon is usually found on bare rock outcrops or sparsely vegetated portions of rocky cliff faces or cliff bases in diverse lowland mesic forests at elevations between 180 and 800 meters (590 and 3,000 feet). Plants associated with the Lawai population of *Schiedea spergulina* var. *leiopoda* are *Bidens sandvicensis* (kookoolau), *Doryopteris* (kumuniu), *Peperomia leptostachya*, and *Plectranthus parviflorus* (alaala wai nui) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Schiedea spergulina* var. *leipoda*.

Historically, *Schiedea spergulina* var. *leiopoda* was found on a ridge on the east side of Hanapepe on Kauai (HHP 1994). One population of 50 to 100 individuals of this variety is now known to grow in Lawai Valley on Kauai on privately owned land (HHP 1994; NTBG 1994; USFWS 1994a).

e. Reasons for Decline and Current Threats

The major threats to *Schiedea spergulina* var. *leipoda* are habitat destruction by feral goats and competition with introduced plants. This variety is threatened by competition with alien plant taxa such as koa haole, lantana, and *Furcraea foetida* (Mauritius hemp), and individuals are also damaged and destroyed

by rock slides. This variety is potentially threatened by pesticide use in nearby sugarcane fields as well as stochastic extinction and/or reduced reproductive vigor due to the small number of existing individuals (USFWS 1994a).

f. Conservation Measures

NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Schiedea spergulina* var. *leipoda* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

33. ***Schiedea spergulina*** **var. *spergulina*** - RP# 9

a. Description and Taxonomy

Appendix B contains a line drawing of *Schiedea spergulina* var. *spergulina*.

Please refer to section on Description and Taxonomy for *Schiedea spergulina* var. *leipoda*.

b. Life History

Little is known about the life history of *Schiedea spergulina* var. *spergulina*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This taxon is usually found on bare rock outcrops or sparsely vegetated portions of rocky cliff faces or cliff bases in diverse lowland mesic forests at elevations between 180 and 800 meters (590 and 3,000 feet). Plant taxa associated with *Schiedea spergulina* var. *spergulina* include ahinahina, Chinaberry, lantana, Sacramento bur, and *Nototrichium sandwicense* (kului) (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Schiedea spergulina* var. *spergulina*.

Schiedea spergulina var. *spergulina* is more numerous than *S. spergulina* var. *leipoda*. It was once found in Olokele Canyon but is now known only from Kalalau Rim and four locations in Waimea Canyon on State land (HHP 1994). One population contains only five plants, whereas others number in the thousands. These populations are estimated to total more than 5,000 individuals (HHP 1994; USFWS 1994a; S. Perlman, personal communication 1994)).

e. Reasons for Decline and Current Threats

Schiedea spergulina var. *spergulina* is threatened by competition with alien taxa, including daisy fleabane and lantana. The area in which this variety grows is used heavily by feral

goats, and there is evidence that plants are being browsed and trampled (USFWS 1994a).

f. Conservation Measures

NTBG presently has seeds in short-term storage (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Schiedea spergulina* var. *spergulina* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

34. ***Solanum sandwicense*** - RP# 2

a. Description and Taxonomy

Appendix B contains a line drawing of *Solanum sandwicense*.

The information in this section is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a).

William Jackson Hooker and G.A.W. Arnott (1830-1841) described *Solanum sandwicense* based upon a specimen collected in 1826 or 1827 on Oahu during the voyage of H.M.S. Blossom. The plant was named for the Sandwich Islands, an older name for the Hawaiian Islands. Other names by which portions of this species have been known include: *S. hillebrandii* (St. John 1969a), *S. kauaiense* (Hillebrand 1888), *S. sandwicense* var.? *kavaiense* (Gray 1862), *S. woahense* (Symon 1990), and *S. woahense* var. *eroso-crenulatum* (Symon 1990). In the current treatment of this genus,

Symon (1990) considers the Oahu and Kauai populations as *Solanum sandwicense* and recognizes no subspecific taxa.

Solanum sandwicense, a member of the nightshade family, is a large sprawling shrub that grows up to 4 meters (13 feet) tall. The younger branches are more densely hairy than older branches. The oval leaves are usually 10 to 15 centimeters (4 to 6 inches) long and 5 to 14 centimeters (2 to 5.5 inches) wide and have up to four lobes along the margins. Leaf stalks are 2 to 4 centimeters (0.8 to 1.6 inches) long. On the flowering stem, a few to as many as 40 flowers are grouped in threes, with each flower on a stalk about 15 millimeters (0.6 inches) long, bent at the end so that the flower faces downward. The corolla is white with a faint purplish stripe, each lobe is curved somewhat backward. Stamens are attached low on the corolla tube, with anthers curved inward. The fruit is a berry 13 to 15 millimeters (0.5 to 0.6 inches) in diameter, black when ripe. This species differs from others of the genus in having dense hairs on young plant parts, a greater height, and its lack of prickles (Gray 1862, St. John 1969a, Sohmer and Gustafson 1987, Symon 1990).

b. Life History

Little is known about the life history of *Solanum sandwicense*. Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

This species is typically found in open, sunny areas at elevations between 760 and 1,220 meters (2,500 and 4,000 feet) in diverse lowland to montane mesic forests and occasionally in wet forests. Associated plant taxa include koa, ohia, uluhe, and wet forest plants such as kopiko, hoio, and alani (USFWS 1994a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Solanum sandwicense*.

Historically, *Solanum sandwicense* was known from widely scattered populations throughout the Waianae Mountains and southern portions of the Koolau Mountains on Oahu (HHP 1994). On Kauai, this species was known from locations in the Kokee region bounded by Kalalau Valley to the north, Milolii Ridge to the west, and Kawaikoi to the east, extending southward to the Hanapepe River (HHP 1994). On Oahu, this species is currently known from a single population with one individual on privately owned land in Honouliuli Preserve (NTBG 1994). One other recent population on Oahu was destroyed by a landslide in 1986 (HHP 1994, USFWS 1994a). The three Kauai populations are on private and State land, and most are from Kokee and Na Pali Coast State Parks. The four extant populations contain a total of about 20 plants (Bruegmann 1990, CPC 1990, HHP 1994, USFWS 1994a).

e. Reasons for Decline and Current Threats

The major threats to populations of *Solanum sandwicense* on Kauai are habitat degradation by feral pigs and competition with alien plant taxa. Alien taxa that have heavily invaded this species' habitat on Kauai include: banana poka, prickly Florida blackberry, strawberry guava, *Hedychium gardnerianum* (kahili ginger), and Japanese honeysuckle. This species is also threatened by fire, over-collecting for scientific purposes, stochastic extinction, and/or reduced reproductive vigor due to the small number of existing individuals. All Oahu populations of *Solanum sandwicense* except one are now apparently extinct, the result of its habitat being destroyed by urbanization, landslides, feral pigs, and weedy alien taxa (USFWS 1994a).

f. Conservation Measures

Solanum sandwicense has been successfully propagated and grown *ex situ* by Lyon Arboretum, NTBG, and Waimea Arboretum. Present holdings at Lyon Arboretum consist of 12 plants in the tissue culture lab (C. Lamoureux, personal communication 1995). NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995), and Waimea Arboretum has two plants (J. Llop, personal communication 1995).

The Kauai District DOFAW recently completed fencing in Kuia NAR, which protects the *Solanum sandwicense* population there (G. Kawakami, personal communication 1994).

TNCH is planning on outplanting approximately 10 seedlings of *Solanum sandwicense* in Honouliuli Preserve on Oahu (Jennifer Crummer, TNCH, personal communication 1995). No additional conservation measures are being conducted for *Solanum sandwicense* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral pigs and alien weed threats. Management actions necessary to protect the remaining wild individual on Oahu include selective weeding of Christmas berry and *Passiflora suberosa*, as well as regular monitoring (J. Crummer, personal communication 1995). Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

35. *Stenogyne campanulata* - RP# 5

a. Description and Taxonomy

No line drawing is available for *Stenogyne campanulata*.

The information in this section is taken directly from the listing package covering six of the Kauai cluster taxa (USFWS 1992a).

Stenogyne campanulata was discovered in 1986 by Steven Montgomery on sheer, virtually inaccessible cliffs below the upper rim of Kalalau Valley on Kauai. In 1989, Stephen Weller and Ann Sakai described the plant as a new species, naming it for the flowers' bell-shaped calyces.

Stenogyne campanulata is a member of the mint family (Lamiaceae), described as a vine with four-angled, hairy stems. The hairy leaves are broadly oval, about 5 centimeters (2 inches) long and 3 centimeters (1 inch) wide. The flowers occur in clusters of about six per leaf axil. The very broadly bell-shaped, hairy calyces are about 13 millimeters (0.5 inches) long, with teeth that are 3 millimeters (0.1 inches) long and 5 millimeters (0.2 inches) wide at the base. The petals are fused into a straight, hairy, white tube about 13 millimeters (0.5 inches) long, with short purple lobes. The fruits of this species have not been seen, but the fruit of all other members of this genus are fleshy nutlets. *Stenogyne campanulata* is distinguished from closely related species by its large and very broadly bell-shaped calyces that nearly enclose the relatively small, straight corollas, and by small calyx teeth that are half as long as wide (Weller and Sakai 1990).

b. Life History

Little is known about the life history of *Stenogyne campanulata*. Flowering cycles, pollination vectors, seed

dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Stenogyne campanulata grows on the rock face of a nearly vertical, north-facing cliff at an elevation of 1,085 meters (3,560 feet). The associated shrubby vegetation includes native species such as ahinahina, *Lepidium serra* (anaunau), *Lysimachia glutinosa*, olomea, and *Remya montgomeryi*, and alien species such as prickly Florida blackberry and daisy fleabane (USFWS 1992a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Stenogyne campanulata*.

Stenogyne campanulata is known only from the single population which was originally discovered on the cliffs of Kalalau to below Puu o Kila. The population numbers about 50 individuals and is on State-owned land in Na Pali Coast State Park.

e. Reasons for Decline and Current Threats

The restriction of this species to virtually inaccessible cliffs suggests that predation by goats may have eliminated it from more accessible locations. Goat predation and habitat degradation remain the primary threat. Goats may limit seedling establishment in more accessible areas and if they reach existing plants, losses could occur. Feral pigs have disturbed vegetation in the vicinity of the only known population. Erosion caused by goats or pigs exacerbates the potential threat of landslides to this population. Daisy fleabane and prickly Florida blackberry are the primary alien plants threatening *Stenogyne campanulata*. The small size of the single known population and its restricted

distribution (probably well under 45 square meters (500 square feet) in area) are serious potential threats to the species. The limited gene pool may depress reproductive vigor, or a single environmental disturbance such as a landslide could destroy all known extant individuals (USFWS 1992a).

f. Conservation Measures

Stenogyne campanulata has been successfully propagated and grown *ex situ* by NTBG, and NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995). No additional conservation measures are being conducted for *Stenogyne campanulata* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be undertaken immediately, as well as the protection of remaining wild individuals from feral goats, feral pigs and alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

36. ***Wilkesia hobdyi*** - RP# 2

a. Description and Taxonomy

There is no line drawing available for *Wilkesia hobdyi*.

The information in this section is taken directly from the listing package covering this species (USFWS 1992b).

Wilkesia hobdyi was discovered by Robert W. Hobdy on Polihale Ridge, Kauai, in 1968. He sent a specimen of the plant

to the late Dr. Harold St. John, a botanist who was affiliated with the Bishop Museum herbarium. St. John described the plant as a new species and named it in Hobdy's honor (St. John 1971).

Wilkesia hobdyi, a member of the sunflower family (Asteraceae), is a shrub about 60 centimeters (2 feet) tall, which branches from the base. The tip of each branch bears a tuft of narrow leaves which are about 1.3 centimeters (0.5 inches) wide and about 7.5 to 15 centimeters (3 to 6 inches) long. The leaves, which are in whorls, are joined together into a short sheathing section at their bases. The flower heads are in clusters of about 25 to 45 centimeters (10 to 18 inches) long. Each head is cream colored and about 2 centimeters (0.75 inches) in diameter (Carr 1982a, 1990; St. John 1971).

b. Life History

This species is probably pollinated through outcrossing and is probably self-incompatible. Insects are the most likely pollinators. Reproduction and seedling establishment are occurring and appear sufficient to sustain the populations. Flowering has been observed most often in the winter months, but also during June. Fruits may be dispersed when they stick to the feathers of birds. Densities reach one plant per square meter (approximately one square yard) in localized areas and hybridization with *Wilkesia gymnoxiphium* may be occurring (Carr 1982a).

c. Habitat Description

Wilkesia hobdyi grows in degraded cliff sites and very dry ridges 275 to 400 meters (90 to 1,312 feet) in elevation (Wagner et al. 1990). Most populations are surrounded by shrubby alien vegetation such as koa haole, lantana, and sourbush; however, the associated native vegetation includes *Myoporum sandwicense* (naio),

Sida fallax (ilima), *Waltheria indica*, aalii, and *Eragrostis variabilis* (S. Perlman, personal communication 1995).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Wilkesia hobdyi*.

The Polihale ridge population on the island of Kauai is believed to contain between 250 and 300 plants (HHP 1994). In 1982, a population of about 100 individuals of the species was discovered on the adjacent Kaaweiki ridge (HHP 1994). A third population, estimated to be between 10 and 50 individuals, was discovered on a cliff face in Waiahuakua Valley in 1988 (HHP 1994). There are also additional populations at Makaha (50 plants) and Pohakuao (ten plants) (K. Wood, personal communication 1994). Today, only these 5 populations, estimated to comprise between 420 to 510 individuals, are known. All populations occur on State-owned land, on the island of Kauai. Two of the populations are in the Puu Ka Pele Forest Reserve, growing on the north-facing, nearly vertical rock outcrops near the summits of the adjacent Polihale and Kaaweiki ridges. The third population grows on a cliff face in Waiahuakua Valley, on the boundary between the Hono O Na Pali NAR and the Na Pali Coast State Park, approximately 16 kilometers (10 miles) northeast of the other two populations.

Three additional, unconfirmed observations, which may be of this species, have been reported. The observations were made from a distance with binoculars. The first observation was made by the State botanist during a survey of the Na Pali Coast in 1979, and was in the Nualolo-Aina Valley (HHP 1994). The population comprised about 10 plants (USFWS 1992b). The plants were not seen during a follow-up survey of the area 5 years later, and the observer stated that the species may be a good indicator plant for the presence of grazing animals (USFWS 1992b). The second observation was that of a single plant on a cliff wall in Milolii

Valley (HHP 1994; USFWS 1992b). The sighting was made during a botanical survey of the Na Pali Coast in 1980, and the plant was not seen during a subsequent survey in 1989 (USFWS 1992b). The third observation, made on March 6, 1991, was of an estimated 30 to 40 plants seen by binoculars on Haeleele Ridge, the ridge south of Polihale Ridge (USFWS 1992b). The known populations and the unconfirmed sightings are all from the nearly vertical rock outcrops on the Na Pali Coast of western Kauai. There are at least two other species of plants in this area that, from a distance, superficially resemble *Wilkesia hobdyi*; it is not known how it was determined that the observations were of *W. hobdyi*.

e. Reasons for Decline and Current Threats

The greatest immediate threats to the survival of this species are habitat disturbance and browsing by feral goats. The goats browse on the plant and their activity in the area accelerates erosion and facilitates the encroachment of competing, naturalized plants. Although the low number of individuals and their restricted habitat could be considered a potential threat to the survival of the species, the plant appears to have vigorous reproduction and should survive indefinitely if goats were eliminated from its habitat (USFWS 1992b).

f. Conservation Measures

Wilkesia hobdyi has been successfully propagated and grown *ex situ* by NTBG, and NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995). The Kauai District DOFAW has outplanted 20 individuals of this taxon at Kalepa and Nounou Forest Reserves, and additional outplanting of this taxon is planned for an exclosure at Haeleele Ridge in Puu Ka Pele Forest Reserve (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Wilkesia hobdyi*

except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

37. ***Xylosma crenatum*** - RP# 5

a. Description and Taxonomy

Appendix B contains a line drawing of *Xylosma crenatum*.

The information in this section is taken directly from the listing package covering six of the Kauai cluster taxa (USFWS 1992a).

Xylosma crenatum was first collected in 1917 by Charles Forbes on the west side of the Waimea drainage basin. However, the collection was misidentified as *Hibiscus waimeae* (HHP 1990s). Over 50 years later (in 1968), Robert Hobdy made the second collection of this plant, along the banks of Mohihi Stream at the edge of the Alakai Swamp. In 1972, Harold St. John recognized the plant as a distinct species, and named it *Antidesma crenatum*, after the rounded teeth along the leaf edges (St. John 1972). In 1976, St. John transferred the name to the genus *Xylosma*.

Xylosma crenatum is a dioecious (unisexual) tree in the flacourtia family (Flacourtiaceae), growing up to 14 meters (46 feet) tall, and with dark gray bark. The somewhat leathery leaves are oval to elliptic-oval, about 10 to 20 centimeters (4 to 8 inches) long and 6.5 to 10 centimeters (2.5 to 4 inches) wide, with coarsely toothed edges and moderately hairy undersides. The female flowers (male flowers have not been described) occur in clusters of 3 to 11 per leaf axil. The four oval sepals are about 2.5 millimeters (0.1 inches) long; petals are absent. The young

berries are oval to elliptic-oval and about 7 millimeters (0.3 inches) long (mature fruits have not been seen). More coarsely toothed leaf edges and hairy undersides of the leaves distinguish *Xylosma crenatum* from the other Hawaiian member of this genus (St. John 1972, Wagner et al. 1990).

b. Life History

Little is known about the life history of *Xylosma crenatum.* Flowering cycles, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, and limiting factors are unknown.

c. Habitat Description

Xylosma crenatum is known from diverse koa - ohia montane mesic forest at an elevation of about 975 to 1,065 meters (3,200 to 3,500 feet), sometimes along stream banks or within a planted conifer grove. Associated species include the native manono and *Athyrium sandwicensis* and alien strawberry guava (USFWS 1992a).

d. Historic and Current Range and Population Status

Appendix C contains a map of the historic and current range of *Xylosma crenatum.*

Xylosma crenatum was originally known from only two sites on Kauai: along upper Nualolo Trail in Kuia NAR and along Mohihi Road between Waiakoali and Mohihi drainages in Na Pali-Kona Forest Reserve (HHP 1994, USFWS 1992a). There are still six individuals along Nualolo Trail (S. Perlman, personal communication 1994; K. Wood, personal communication 1994). Other populations have recently been discovered in three new areas: Honopu Valley in Kokee State Park (one individual), Nawaimaka Valley in Na Pali-Kona Forest Reserve (five individuals), Mahanaloa Valley (one individual) (S. Perlman, personal communication 1994; K. Wood,

personal communication). *Xylosma crenatum* is found only on State-owned land on the island of Kauai.

e. Reasons for Decline and Current Threats

The small number of individuals and scattered distribution make this species vulnerable to human or natural environmental disturbance. *Xylosma crenatum* is also threatened by competition from alien plants, particularly strawberry guava. In addition, feral pigs may threaten this species (USFWS 1992a).

f. Conservation Measures

Xylosma crenatum has been successfully propagated and grown *ex situ* by NTBG, and NTBG presently has seeds in short-term storage as well as plants growing in their garden (D. Ragone, personal communication 1995). Present holdings at Lyon Arboretum consist of seed in the tissue culture lab (C. Lamoureux, personal communication 1995).

The Kauai District DOFAW is planning on outplanting this taxon, and fencing was recently completed to protect the Kuia NAR population (G. Kawakami, personal communication 1994). No additional conservation measures are being conducted for *Xylosma crenatum* except those mentioned in the Overall Conservation Efforts section of this plan.

g. Needed Recovery Actions

In order to prevent this taxon from going extinct, propagation efforts and the maintenance of adequate genetic stock *ex situ* should be continued, as well as the protection of remaining wild individuals from alien weed threats. Please refer to the Stepdown Narrative section of this plan for the overall recovery strategy.

RECOVERY

A. Objectives

Objectives for stabilizing, downlisting, and delisting are provided for the Kauai 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 ESA as any species which is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species which 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: *Hibiscus clayi*, *Melicope haupuensis*, *Melicope knudsenii*, *Melicope pallida*, *Melicope quadrangularis*, *Munroidendron racemosum*, *Nothocestrum peltatum*, *Pteralyxia kauaiensis* and *Xylosma crenatum*.

The short-lived perennials in this plan are: *Brighamia insignis*, *Chamaesyce halemanui*, *Cyanea asarifolia*, *Cyrtandra limahuliensis*, *Delissea rhytidosperma*, *Diellia pallida*, *Dubautia latifolia*, *Exocarpos luteolus*, *Hedyotis cookiana*, *Hedyotis st.-*

johnii, *Lipochaeta fauriei*, *Lipochaeta micrantha* var. *exigua*, *Lipochaeta micrantha* var. *micrantha*, *Lipochaeta waimeaensis*, *Lysimachia filifolia*, *Peucedanum sandwicense*, *Phyllostegia waimeae*, *Poa mannii*, *Poa sandvicensis*, *Poa siphonoglossa*, *Remya kauaiensis*, *Remya montgomeryi*, *Schiedea apokremnos*, *Schiedea spergulina* var. *leiopoda*, *Schiedea spergulina* var. *spergulina*, *Solanum sandwicense*, *Stenogyne campanulata*, and *Wilkesia hobdyi*.

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 Plant Recovery Coordinating Committee (HPPRCC), 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 Kauai cluster taxa so that more meaningful recovery objectives can be quantified. 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.

Interim Objectives

The interim objective is to stabilize all existing populations of the Kauai cluster 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 Kauai, 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 Kauai 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 Kauai and at least one 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 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 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.

B. Stepdown Outline

1. Protect habitat, control threats and monitor.

    11. Provide long-term protection of habitat.

        111. Identify and map all extant populations.

        112. Identify areas for preservation (i.e., management units).

        113. Ensure long-term protection of habitat.

    12. Identify and control threats.

        121. Develop threat management plans for each protected area.

        122. Control feral ungulates.

            1221. Determine fencing strategy.

            1222. Construct and maintain fencing.

            1223. Remove ungulates within fenced areas.

            1224. Monitor fenced areas for ungulate damage and effects on weeds.

            1225. Consider control of ungulates through eradication programs or establishment of game preserves.

        123. Conduct essential alien plant control.

        124. Provide necessary fire protection.

        125. Control other introduced animals.

            1251. Control rodents.

            1252. Control slugs.

            1253. Control insects.

            1254. Control red jungle fowl.

        126. Control disease, if necessary.

        127. Ensure availability of pollination vectors, if necessary.

128. Protect areas from direct threats from humans.

129. Maintain genetic stock *ex situ*.

1210. Prevent introduction of new alien species to Hawaii.

1211. Control other threats, as necessary.

13. Monitor status of wild populations.

2. Expand existing wild populations.

21. Identify populations for expansion.

22. Identify material to be used for expansion.

23. Determine optimum propagation methods and propagate *ex situ*.

24. Prepare sites and plant.

25. Monitor and maintain new individuals.

3. Conduct essential research.

31. Collect diagnostic data on crucial associated ecosystem components.

32. Map alien vegetation.

33. Study various aspects of growth.

34. Study reproductive viability.

35. Determine parameters of viable populations.

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

37. Determine effective control methods to combat threats found by completing task # 36.

38. Evaluate results and use in future management.

4. Reestablish wild populations within the historic range.

41. Identify reestablishment sites.

42. Protect reestablishment sites.

43. Identify material to be used for reestablishment.

44. Determine optimum propagation methods and propagate *ex situ*.

45. Prepare reestablishment sites and plant.

46. Monitor and maintain new populations.

5. Validate recovery objectives.

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

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

53. Refine/revise downlisting and delisting criteria.

6. Design and implement a public education program.

C. Stepdown Narrative

1. Protect habitat, control threats and monitor.

Given the degraded nature of the Kauai plant cluster's habitat, their precariously low numbers, and the severity of the threats, the highest priority actions must be aimed at protecting all extant wild individuals and populations, managing habitat to enhance survival and ensuring maintenance of adequate genetic stock *ex situ*. Emergency actions are crucial for those 10 taxa nearest extinction: *Cyanea asarifolia*, *Delissea rhytidosperma*, *Diellia pallida*, *Hibiscus clayi*, *Melicope haupuensis*, *Melicope quadrangularis*, *Nothocestrum peltatum*, *Phyllostegia waimeae*, *Solanum sandwicense*, *Xylosma crenatum*. A monitoring program to track the status of the populations, and to assess the effectiveness of threat management, will also be essential.

11. Provide long-term protection of habitat.

Habitat of the Kauai cluster taxa that is not currently afforded long-term protection from threats, such as development, agriculture and alien ungulates maintained for hunting programs, should be identified and protected.

111. Identify and map all extant wild populations.

Protection of all extant populations will involve locating all individuals, mapping precise locations, and providing this information to the land managers. 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 information (including directions, maps, global positioning system (GPS) data, and narratives) is recommended for each site.

112. Identify areas for preservation (i.e., management units).

Areas for preservation, which, ideally, contain multiple populations of multiple species and can be managed under a single, coordinated, management plan must be chosen. These sites should include areas adequate for buffer zones and fire breaks and for expansion of existing populations and establishment of new populations when necessary. Similar areas should be designated to include new populations of any Kauai cluster taxa found after the initial areas are chosen. Management units should be based on ecosystem characteristics and can incorporate

adjacent areas owned by different landowners. The Hawaii and Pacific Plant Recovery Coordinating Committee and Plant Recovery Teams should assist the USFWS, the Department of Land and Natural Resources (DLNR), and other landowners and managers in identifying these management units.

113. Ensure long-term protection of habitat.

The protection currently provided to these taxa by various landowners should be continued or pursued. This includes, but is not limited to, protection provided by federal and State laws, regulations, and policies, and management plans and policies of federal, State, and private landowners.

Most of the Kauai plant cluster taxa occur on lands owned and/or managed by the State of Hawaii. The State should ensure that all departments within the State that are responsible for activities on these lands, such as land zoning, development projects, forestry projects, recreational programs, etc., are made aware of the presence of these listed plant taxa. In addition, the State should establish procedures to ensure that all State activities in the area are reviewed with respect to their potential impact on the listed plant taxa, with appropriate measures taken to minimize or preclude all negative impacts. DLNR should develop and implement long-term management plans for the Kauai cluster taxa on their lands.

The National Park Service is the only federal agency with lands important to endangered taxa of the Kauai cluster. Park lands are already protected and managed to benefit endangered species. The Park Service should be encouraged to develop and implement an Endangered Species Management Plan for the *Peucedanum sandwicense* population at Kalaupapa National Park. The Park Service will undergo section 7 consultation with the USFWS for any actions likely to affect this taxon.

The remaining habitat is owned or managed by the City and County of Honolulu, TNCH, McBryde Sugar Company, Kamehameha Schools/Bishop Estate, Campbell Estate, Alexander and Baldwin, Inc., and various private individuals. Many of these landowners have already taken significant steps toward the protection of endangered plants on their lands. Steps should be taken to ensure that all such landowners are aware of the presence of the listed taxa on their lands and DLNR and/or USFWS should assist the landowners, as necessary, in developing and implementing long-term management plans for these lands.

12. Identify and control threats.

Management of protected areas to reduce and/or eliminate threats to the Kauai cluster taxa, is essential to the survival and recovery of these taxa.

121. Develop threat management plans for each protected area.

Development of threat management plans for each protected area should be carried out in as cooperative a manner as possible, with every attempt made to enter into a partnership with landowners on whose lands the plants may occur and whose lands lie adjacent to management units. Management plans should be as all-encompassing as possible, incorporating several protected areas into one overall plan for restoration and management of the habitat on Kauai and other islands to support the 37 taxa identified in this recovery plan, along with other native components of the habitat.

These management plans should be tailored to fit the unique needs of the areas covered, and may include some or all of the tasks outlined below as well as others which become necessary as more is learned about the area and species. Among the actions that must be included in all, or the majority of, the management plans for these 37 taxa are actions needed to immediately protect the plants from grazing and trampling by feral ungulates, competition from alien plants, and fire. Other actions that may be specific to certain taxa and management units only are: protection from other introduced species, such as insects, rodents, and the red jungle fowl, and protection from disease.

122. Control feral ungulates.

The numbers of goats, pigs, and other feral ungulates in the forests of Hawaii are extensive. Controlling these ungulates to the point where they are no longer impacting native vegetation is absolutely imperative. Most of the taxa included in this plan can not afford to wait many years for protection from ungulates. The most effective method currently known for providing immediate protection from feral ungulates in Hawaii is fencing of discrete management units. Although this approach is costly, it does work, as demonstrated at Hawaii Volcanoes and Haleakala National Parks and elsewhere, and is a feasible solution for feral mammal control in Hawaii (Stone 1992). In order to provide stable natural communities in which the Kauai cluster taxa can survive and reproduce without constant species-specific management, fencing must

ultimately be done on a large scale, protecting whole drainages rather than creating "postage stamp" exclosures.

1221. Determine fencing strategy.

A combination of short-term, small-scale fencing to protect those populations under immediate threat from ungulates and longer-term, large-scale fencing may be necessary. However, even "small" exclosures should 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). As a general guideline, a minimum-sized exclosure should have its perimeter located at least 50 meters (164 feet) distant from the nearest individual of the target species. This should be viewed as a general guideline. 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 that is resistant to invasion of alien species). To reduce maintenance costs, fences should be constructed along ridgelines and tied into streamcourses at natural barriers (such as the tops of waterfalls) as much as possible.

1222. Construct and maintain fencing.

Once the best method and configuration for fencing each site is determined, fencing and maintenance should begin as soon as possible. Fences should be impervious to all ungulates found in the area(s). Ongoing inspection and maintenance of fences is necessary to ensure the continued exclusion of ungulates from the fenced areas.

1223. Remove ungulates within fenced areas.

Once the fences have been completed, 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 Hawaii. 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 in extremely rugged terrain. Hunters and others who will be working in the habitat of the Kauai cluster taxa should be apprised of the existence and whereabouts of the plants so that they do not inadvertently damage them.

1224. Monitor fenced areas for ungulate damage and effects on weeds.

Ongoing monitoring for ungulates within the large fenced areas is necessary to ensure their continued absence. Monitoring should also record the possible increased vigor of alien plants which may be released from grazing pressure, and the effects of this on the Kauai cluster taxa.

1225. Consider control of ungulates through eradication programs or establishment of game preserves.

Ideally, island-wide programs to eradicate feral ungulates should be instigated and supported where these taxa occur. Fences are a maintenance-intensive and not altogether foolproof method of protecting habitats (Stone 1992) necessary for recovery of the Kauai cluster taxa. Removal of feral ungulates will also slow down the degradation of watershed lands. However, public support of hunting is fervent and the likelihood of acceptance of an ungulate eradication program seems remote. Pursuing the establishment of game preserves in Hawaii, where areas are set aside for hunting of game animals, should be a high priority within the State.

123. Conduct essential alien plant control.

One of the most important aspects of habitat management for the Kauai cluster taxa is the control of alien weeds. This may become even more important if the removal of ungulates relieves grazing and browsing pressure on alien plants. It is critically important to realize that habitat disturbance by weed removal activities can be highly detrimental to native ecosystems. Steps should always be taken to avoid both direct and indirect damage to the environment. Potential damage can include trampling of endangered taxa, the introduction of alien

plant seeds and the creation of inroads for remaining ungulates and subsequent pathways for invasion of alien plants.

Weed control should begin immediately for each population where necessary, beginning in the immediate vicinity of the existing plants and continuing until control is achieved in the full management site. Effective weed control methods must be determined. Control methods may include hand-pulling and possibly local herbicide application.

Control efforts should be supervised by a botanist experienced in safe control methods to ensure 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 threatened and endangered species, during weed removal.

Follow-up visits to each site are necessary to ensure that weeds are permanently controlled. Weed control must be ongoing and sites should be monitored periodically to determine when additional intervention is necessary.

124. Provide necessary fire protection.

Protection from fire is critical to the survival of the Kauai cluster plants, particularly for those in mesic or dry habitats. Protection must be both local and on a larger scale in order to prevent fires from spreading to areas where the plants grow.

Plans to protect each site from fire should be developed and implemented. 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 management areas wherever feasible. This minimum width may not be sufficient to protect populations from fire in especially dry conditions.

125. Control other introduced animals.

Threats not already addressed include predation by rodents, disturbance by red jungle fowl and possibly more host-specific pests. Monitoring and control of such pests should be implemented using currently existing control methods. Additional control methods will be devised under research task # 37.

1251. Control rodents.

Control rodents as needed to allow reproduction of endangered plant taxa. Intensive rodent control over a period prior to and during fruit production is recommended in order to have a viable crop of seeds for collection and *ex situ* propagation. Existing methods for rodent control include trapping, poisoning, and/or the use of rodent barriers. Currently, rodents are known to be a threat to *Delissea rhytidosperma* and are a probable threat to *Cyanea asarifolia, Munroidendron racemosum* and *Pteralyxia kauaiensis.*

1252. Control slugs.

Control slugs as needed. Currently, slugs are known to be a threat to *Cyanea asarifolia* and are suspected to be a threat to other Kauai cluster taxa.

1253. Control insects.

Methods to control insects that threaten the Kauai cluster taxa should be devised and implemented. Currently, the black twig borer is a potential threat to all four *Melicope* species covered in this plan. The Carmine spider mite is a threat to wild and cultivated individuals of *Brighamia insignis*, an insect in the longhorned beetle family is a possible threat to wild *Munroidendron racemosum*, and the two-spotted leaf hopper is a threat to many of the Kauai plant cluster taxa.

1254. Control red jungle fowl.

Disturbance by red jungle fowl is a threat to the Makaha Valley population of *Nothocestrum peltatum*. Methods for control of this alien species should be devised and implemented.

126. Control disease, if necessary.

If the results of task # 36 show that disease is a threat to any of the Kauai cluster taxa, then control measures should be devised and implemented. Disease is currently known to be a possible threat to *Dubautia latifolia*.

127. Ensure availability of pollination vectors, if necessary.

Based on the results of research task # 34, measures should be established to ensure that pollination vectors remain available to the Kauai 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.

128. Protect areas from direct threats from humans.

Areas where the Kauai cluster taxa grow should be protected as much as possible from hikers, vehicles, and other possible human disturbances. As a part of protection of areas from human use, public awareness and education regarding these endangered taxa should be fostered.

Signs designating sensitive environmental areas and/or research areas should be placed near sites where human contact may occur. "Kapu/No Trespassing" signs may be necessary to prohibit or limit 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 which 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 which pass through habitat of the Kauai cluster taxa should be rerouted or closed to prevent ready access to these areas. In cases where this is not feasible, care should be taken at any time during road or trail maintenance in or near habitat of the endangered taxa to avoid practices which would cause excessive erosion or other damage to the Kauai cluster plants or their habitat; all such activities should be closely monitored by an appropriate conservation agency.

129. Maintain genetic stock *ex situ*.

Cultivated populations of each Kauai 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. 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 and/or research demand.

This task is important for all the taxa in this plan and is a priority for those taxa with fewer than 100 individuals. It should be noted, however, that cultivation of these plants is not a substitute for their preservation in the wild.

As broad a complement as possible of the existing genetic stock for each taxon should be preserved. For each identifiable population (either from extant sites or traceable, pure, cultivated material), genetic material from as many individuals as feasible should be collected. Collection methods and quantities of materials collected should be devised so as to have minimal impact on wild populations. All collected materials should be labelled accurately as to exact origin, collection date, etc.

Seeds of each taxon should be collected and entrusted to seed banks for long-term storage using the best available techniques for preservation. Seeds collected for long-term storage should be tested for viability when first collected for baseline comparison and periodically retested and recollected as necessary.

1210. Prevent introduction of new alien species to Hawaii.

Introduction of alien species to the State of Hawaii and between islands needs to be halted to prevent additional new threats to the Kauai cluster taxa and their habitats. Support should be given to legislation, programs, or activities which limit the possibility of accidental or deliberate introduction of potentially detrimental alien species. The success of such programs or activities would contribute to the perpetuation of the endangered species in this plan, the quality of all native ecosystems, as well as agricultural concerns in the State of Hawaii.

1211. Control other threats, as necessary.

The need for control of other threats may become apparent as more is learned about the Kauai cluster taxa. New threats, such as introduction of new alien species, may also occur. As new threats arise, management actions to reduce and/or eliminate their effects on the Kauai cluster taxa should be implemented.

13. Monitor status of wild populations.

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

2. Expand existing wild populations.

It is hoped that by eliminating current threats through management, populations of the Kauai cluster taxa will expand naturally. However, in certain special instances, wild populations of the Kauai cluster taxa may need to be augmented. This should be done conservatively and only after careful consideration of all factors involved, particularly the threat of introducing detrimental organisms into the wild populations. Augmentation efforts should always be well-documented as to lineage and methods.

21. Identify populations for expansion.

Populations of each taxon should be evaluated and determination made as to whether they are appropriate for addition of living material. As new occurrences of each taxon are discovered, each new site should be evaluated for potential augmentation. Because of their very low numbers, populations of *Brighamia insignis*, *Chamaesyce halemanui*, *Cyanea asarifolia*, *Delissea rhytidosperma*, *Diellia pallida*, *Dubautia latifolia*, *Hedyotis cookiana*, *Hibiscus clayi*,

Lipochaeta fauriei, *Lipochaeta micrantha* var. *exigua*, *Lipochaeta waimeaensis*, *Lysimachia filifolia*, *Melicope haupuensis*, *Melicope knudsenii*, *Melicope quadrangularis*, *Nothocestrum peltatum*, *Phyllostegia waimeae*, *Poa mannii*, *Poa siphonoglossa*, *Remya montgomeryi*, *Schiedea spergulina* var. *leiopoda*, *Solanum sandwicense*, *Stenogyne campanulata* and *Xylosma crenatum* will probably need to be augmented in order to reach downlisting and/or delisting objectives.

22. Identify material to be used for expansion.

For each selected population, material for expansion should be carefully chosen in order to best approximate the original material which exists or historically existed at the site to avoid genetic contamination of the population. Normally progeny from plants of the same site/population should be used to augment a population to avoid contaminating the existing local gene pool with genetic material from other origins. Exceptions should be cleared with a researcher knowledgeable about the species and its genetic makeup.

23. Determine optimum propagation methods and propagate *ex situ*.

Plants appropriate for the expansion of existing wild populations can be propagated *ex situ*. Several methods are available which may be used to propagate these taxa. The most effective methods and techniques of propagating each taxon need to be determined.

24. Prepare sites and plant.

Selected sites must be prepared and protected appropriately, including the building of exclosures and alien species control.

The selected material should then be planted. Selected materials should be free from pests, diseases, and pathogens which 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 wild populations may have lower resistance to such introductions. In addition, 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).

25. 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 protection and procedures regarding exclosures, ungulate removal, etc., should apply to new sites as have been recommended for existing sites. Any transplants which do not survive should be replaced.

3. 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 Kauai 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.

31. Collect diagnostic data on crucial associated ecosystem components.

Composition of flora and invertebrate, bird, and other fauna populations within each management area should be established to attempt to gain an understanding of any relationships between these organisms and the Kauai cluster plants and to provide large areas of habitat in which these taxa may survive and reproduce without constant species-specific management.

32. 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 Kauai 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 which 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.

33. 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.

34. Study reproductive viability.

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

Research on new methods of long-term seed storage, such as cryopreservation, is also needed.

35. 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.

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

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

37. Determine effective control methods to combat threats found by completing task # 36.

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

38. Evaluate results and use in future management.

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

4. Reestablish wild populations within the historic range.

If necessary to meet recovery objectives, populations should be reestablished in areas where they are known to have occurred

historically, particularly if genetically uncontaminated, cultivated materials exist which are known to have originated from the historical site. The goal of reintroduction of these taxa is to permanently reestablish viable populations of these taxa in stable and secure conditions. Such reintroduction should be recommended conservatively and only after careful consideration of potential consequences. Genetic purity of populations is a prime concern, as are 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.

41. Identify reestablishment sites.

For each taxon, appropriateness of reintroduction into the wild should be assessed. The choice of reestablishment sites should be based on the best information available (including results of research tasks # 31 and 32 above) in order to match the site conditions to the requirements of the taxon.

Unless new populations are discovered, reestablishment sites on Kauai and other islands within the historical range for *Chamaesyce halemanui, Cyanea asarifolia, Delissea rhytidosperma, Diellia pallida, Hedyotis cookiana, Hedyotis st.-johnii, Hibiscus clayi, Lipochaeta fauriei, Lipochaeta micrantha* var. *exigua, Lipochaeta micrantha* var. *micrantha, Lipochaeta waimeaensis, Lysimachia filifolia, Melicope haupuensis, Melicope quadrangularis, Phyllostegia waimeae, Poa sandvicensis, Poa siphonoglossa, Remya montgomeryi, Schiedea spergulina* var. *leiopoda, Solanum sandwicense, Stenogyne campanulata, Wilkesia hobdyi* and *Xylosma crenatum* will have to be identified in order to reach downlisting and/or delisting objectives.

42. Protect reestablishment sites.

If the sites chosen in task # 41 are outside the management units already established in task # 112, they should be protected as discussed in task # 113 (above).

43. Identify material to be used for reestablishment.

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

44. Determine optimum propagation methods and propagate *ex situ*.

Plants appropriate for the reestablishment of wild populations can be propagated *ex situ*. Several methods are available which may be used to propagate these taxa. The most effective methods and techniques of propagating each taxon need to be determined.

45. Prepare reestablishment sites and plant.

Selected sites must be prepared appropriately, including the building of exclosures and alien species control.

The selected material should then be planted. Selected materials should be free from pests, diseases, and pathogens which 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. In addition, 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).

46. Monitor and maintain new populations.

Newly established populations should be monitored carefully. Ongoing maintenance of each site should occur after initial preparation and planting. The same protection and procedures regarding exclosures, feral animal removal, etc., as have been recommended for existing sites should also apply to reestablishment sites.

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 Kauai cluster taxa, a determination of the number of populations needed for long-term survival should be made.

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

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

53. Refine/revise downlisting and delisting criteria.

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

6. Design and implement a public education program.

A public education program is needed to increase awareness of and support for plant recovery efforts in Hawaii.

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IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated cost for the Kauai 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 the species, stabilize the existing populations and increase the population sizes and numbers. Monetary needs for all parties involved are identified to reach this point, whenever feasible.

Priorities in Column 1 of the following implementation schedule are assigned as follows:

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

Key to Acronyms Used in Implementation Schedule

A&B	-	Alexander & Baldwin, Inc.
ADC	-	U.S. Dept. of Agriculture, Animal Damage Control
BE	-	Kamehameha Schools/Bishop Estate
C	-	Once started, these actions will continue through recovery
C&CH	-	The City & County of Honolulu
CE	-	Campbell Estate
DLNR	-	Department of Land and Natural Resources, Hawaii (includes Division of Forestry and Wildlife (DOFAW) and Division of State Parks (DOSP))
ES	-	U.S. Fish & Wildlife Service, Ecological Services, Honolulu, Hawaii
GF	-	Grove Farm Co., Inc.
HDOA	-	State of Hawaii, Dept. of Agriculture
HHL	-	Hawaiian Home Lands
KCFD	-	Kauai County Fire Dept.
KT	-	Knudsen Trust
LPT	-	Lihue Plantation Co., Ltd.
MCFD	-	Maui County Fire Dept.
NBS	-	National Biological Survey
NPS	-	National Park Service
NTBG	-	National Tropical Botanical Garden, Lawai, Kauai
TBD	-	To be determined at a later date
TNCH	-	The Nature Conservancy - Hawaii
WHR	-	William Hyde Rice, Ltd.

Recovery Plan Implementation Schedule for the Kauai Plant Cluster

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST TO FY2016	COST ESTIMATES ($1,000'S) FY1995	FY 1996	FY 1997	FY 1998	FY1999	Comments
1	1224	Monitor for ungulates in fenced areas	C	* DLNR	180					10	
				ES	180					10	
				NPS	9					0.5	
				TNCH	9					0.5	
1	123	Conduct essential alien plant control	C	* DLNR	1350		30	130	130	130	
				ES	1200			100	100	100	
				NBS	150		30	30	30	30	
				NPS	60			5	5	5	
				TNCH	140			10	10	10	
1	124	Provide necessary fire protection	C	* DLNR	445		25	65	65	65	
				ES	445		25	65	65	65	
				KCFD	76.5		2.5	10.5	10.5	10.5	
				MCFD	40.5		2.5	5.7	5.7	5.7	
				TNCH	53		5	8.2	8.2	8.2	
				NPS	76.5		2.5	10.5	10.5	10.5	
1	1251	Control rodents	C	* DLNR	200			10	10	10	
				ES	200			10	10	10	
1	1252	Control slugs	C	*DLNR	100			5	5	5	
				ES	100			5	5	5	
1	1253	Control insects	TBD	* DLNR	0			TBD			
				ES	0			TBD			
				TNCH	0			TBD			
				NPS	0			TBD			
1	1254	Control red jungle fowl	C	* DLNR	40			2	2	2	
				ES	40			2	2	2	
1	126	Control disease, if necessary	TBD	* DLNR	0			TBD			
				ES	0			TBD			
				TNCH	0			TBD			
				NPS	0			TBD			
1	127	Ensure availability of pollinators if necessary	TBD	* DLNR	0			TBD			
				ES	0			TBD			
				TNCH	0			TBD			
				NPS	0			TBD			
1	128	Protect areas from direct threats from humans	C	* DLNR	310			65	65	10	
				ES	310			65	65	10	
				NPS	19			5	5	0.5	
				TNCH	38			10	10	1	

Recovery Plan Implementation Schedule for the Kauai Plant Cluster

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST TO FY2016	COST ESTIMATES ($1,000'S) FY1995	FY 1996	FY 1997	FY 1998	FY1999	Comments
Protect habitat:											
1	111	Identify and map all extant wild populations	5	* DLNR	250		50	50	50	50	
				ES	50		10	10	10	10	
				TNCH	50		10	10	10	10	
1	112	Identify areas for preservation	3	* DLNR	15		5	5	5		
				ES	3		1	1	1		
				TNCH	3		1	1	1		
1	113	Ensure long-term protection of habitat	2	* ES	25		12.5	12.5			
				DLNR	19.5		9.75	9.75			
				NPS	0.5		0.25	0.25			
				C&CH	0.5		0.25	0.25			
				TNCH	0.5		0.25	0.25			
				A&B	0.5		0.25	0.25			
				BE	0.5		0.25	0.25			
				CE	0.5		0.25	0.25			
				GF	0.5		0.25	0.25			
				HHL	0.5		0.25	0.25			
				KT	0.5		0.25	0.25			
				LPT	0.5		0.25	0.25			
				WHR	0.5		0.25	0.25			
Identify and control threats:											
1	121	Develop management plans for protected areas	5	*DLNR	125				25	25	
				ES	50				10	10	
				TNCH	25				5	5	
				NPS	10				2	2	
1	1221	Determine fencing strategy	2	* DLNR	50		25	25			
				ES	10		5	5			
				TNCH	4		2	2			
				NPS	2		1	1			
				NBS	2		1	1			
1	1222	Construct and maintain fencing	C	* DLNR	1700			150	150	150	
				ES	1700			150	150	150	
				NPS	90			7.5	7.5	7.5	
				TNCH	210			15	15	15	
1	1223	Remove ungulates from fenced areas	10	* DLNR	600				60	60	
				ES	150				15	15	
				NPS	20				2	2	
				TNCH	50				5	5	

Recovery Plan Implementation Schedule for the Kauai Plant Cluster

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST TO FY2016	COST ESTIMATES ($1,000'S) FY1995	FY 1996	FY 1997	FY 1998	FY1999	Comments
1	129	Maintain genetic stock ex situ	O	* DLNR	120	10	10	5	5	5	Ongoing
				ES	120	10	10	5	5	5	
				NTBG	300	50	50	10	10	10	
1	1211	Control other threats, as necessary	TBD	* DLNR	0	TBD					
				ES	0	TBD					
				NPS	0	TBD					
				TNCH	0	TBD					
1	13	Monitor status of wild populations	C	* DLNR	2000			100	100	100	
				ES	1000			50	50	50	
				TNCH	200			10	10	10	
				NPS	100			5	5	5	
2	1225	Consider ungulate eradication	2	*DLNR	10		5	5			
				ES	2		1	1			
2	1210	Prevent introduction of new alien species	O	* DLNR	44	2	2	2	2	2	Ongoing
				FWS-LE	44	2	2	2	2	2	
				HDOA	44	2	2	2	2	2	
		NEED 1 (Protect habitat, control threats and monitor)			14974.5	76	340.5	1274.4	1333.4	1223.9	
2	21	Identify populations for expansion	5	* DLNR	150		30	30	30	30	
				ES	50		10	10	10	10	
				NBS	150		30	30	30	30	
2	22	Identify material to be used for expansion	5	* DLNR	100		20	20	20	20	
				ES	25		5	5	5	5	
				NBS	100		20	20	20	20	
2	23	Determine propagation methods and propagate ex situ	O	* DLNR	4250	350	500	500	500	500	Ongoing
				NTBG	4250	350	500	500	500	500	
				ES	850	60	110	110	110	110	
2	24	Prepare sites and plant	10	* DLNR	0			TBD			
				ES	0			TBD			
				TNCH	0			TBD			
				NPS	0			TBD			
2	25	Monitor and maintain new individuals	C	* DLNR	0				TBD		
				ES	0				TBD		
				TNCH	0				TBD		
				NPS	0				TBD		
		NEED 2 (Expand current populations)			9925	760	1225	1225	1225	1225	

Recovery Plan Implementation Schedule for the Kauai Plant Cluster

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST TO FY2016	COST ESTIMATES ($1,000'S) FY1995	FY 1996	FY 1997	FY 1998	FY1999	Comments
2	31	Study associated ecosystem components	10	*NBS	500		50	50	50	50	
				DLNR	500		50	50	50	50	
				ES	500		50	50	50	50	
2	32	Map alien vegetation	C	*DLNR	315		15	15	15	15	
				ES	210		10	10	10	10	
				TNCH	315		15	15	15	15	
				NPS	105		5	5	5	5	
2	33	Study growth	10	*NBS	500		50	50	50	50	
				ES	500		50	50	50	50	
				DLNR	500		50	50	50	50	
2	34	Study reproductive viability	10	*NBS	500		50	50	50	50	
				ES	500		50	50	50	50	
				DLNR	500		50	50	50	50	
2	35	Determine parameters of viable populations	10	*NBS	500		50	50	50	50	
				ES	500		50	50	50	50	
				DLNR	500		50	50	50	50	
2	36	Determine threat from introduced organisms and disease	5	* DLNR	200		40	40	40	40	
				ES	100		20	20	20	20	
				HDOA	100		20	20	20	20	
				NBS	200		40	40	40	40	
2	37	Determine effective control methods for threats	5	* DLNR	0				TBD		
				NBS	0				TBD		
				ES	0				TBD		
				ADC	0				TBD		
				HDOA	0				TBD		
2	38	Evaluate research results and use in future management	C	* DLNR	190				10	10	
				ES	190				10	10	
				NBS	190				10	10	
				TNCH	19				1	1	
				NPS	19				1	1	
		NEED 3 (Conduct essential research)			7653	0	715	715	747	747	
2	41	Identify reestablishment sites	5	* DLNR	325		65	65	65	65	
				ES	80		15	15	15	15	
				NBS	275		55	55	55	55	

Recovery Plan Implementation Schedule for the Kauai Plant Cluster

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST TO FY2016	COST ESTIMATES ($1,000'S) FY1995	FY 1996	FY 1997	FY 1998	FY1999	Comments
2	42	Protect reestablishment sites	2	* ES	0		TBD				
				DLNR	0		TBD				
				TNCH	0		TBD				
				NPS	0		TBD				
2	43	Identify material for reestablishment	5	* DLNR	25		5	5	5	5	
				NBS	25		5	5	5	5	
				ES	25		5	5	5	5	
2	44	Determine propagation methods and propagate ex situ	0	* DLNR	0					TBD	
				NTBG	0					TBD	
				ES	0					TBD	
2	45	Prepare sites and plant	10	* DLNR	0						
				ES	0						
				TNCH	0						
				NPS	0						
2	46	Monitor and maintain new populations	C	* DLNR	0						
				ES	0						
				TNCH	0						
				NPS	0						
		NEED 4 (Reestablish in former range)			755	0	150	150	150	150	
3	51	Determine number of populations needed for long term survival	3	* NBS	60						
				ES	60						
				DLNR	60						
3	52	Determine number of individuals needed for long term survival	3	* NBS	60						
				ES	60						
				DLNR	60						
3	53	Refine/revise downlisting and delisting criteria	3	* ES	60						
				DLNR	60						
		NEED 5 (Validate recovery objectives)			480	0	0	0	0	0	
3	6	Design and implement a education program	5	*DLNR	25		5	5	5	5	
				ES	25		5	5	5	5	
		NEED 6 (Design and implement public education progrm)			50		10	10	10	10	
TOTAL COST					33787.5	836	2430.5	3364.4	3455.4	3345.9	

APPENDIX A - INDIVIDUALS CONTACTED

Washington, D.C. Agencies

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

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

Chief, Division of Refuges
U.S. Fish and Wildlife Service, DOI
Arlington Square Building, Rm. 670
Arlington, VA 22203

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

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

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Botany Dept., NHB #166
Smithsonian Institution
Washington D.C. 20560

Hawaii and Pacific Plant Recovery Coordinating Committee

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USFWS
911 NE 11th Ave.
Portland, OR 97232-1418

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P.O. Box 52
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111 Washington St. SE
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Olympia, WA 98504-7016

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U.S. Army Corps of Engineers
CEPOD-ED-ME, Bldg. T223
Fort Shafter, HI 96858-5440

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54 South High St.
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Senior Resident Agent
U.S. Fish and Wildlife Service
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P.O. Box 50004
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1151 Punchbowl St., Room 323
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National Park Service
300 Ala Moana Blvd., Room 6305
Honolulu, HI 96813

Dr. William J. Hoe
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Terminal Box 57
Honolulu International Airport
Honolulu, HI 96813

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P.O. Box 2549
Kailua-Kona, HI 96740

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3375 Koapaka St., Suite H420
Honolulu, HI 96819

State of Hawaii

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54 S. High St.
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1151 Punchbowl St., Rm 325
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1151 Punchbowl St.
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3060 Eiwa St. # 306
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Division of State Parks, Outdoor Recreation
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1151 Punchbowl St.
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Mr. George T. Niitani
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P.O. Box 1671
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Mr. Ed Petteys, District Forestry Manager
Division of Forestry and Wildlife
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Mr. Wayne Souza, Planning Branch
Division of State Parks, Outdoor Recreation
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1151 Punchbowl St.
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Mr. Mike Wilson
Chairman, Board of Land and Natural Resources
1151 Punchbowl St.
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Chair-at-Large, Board of Agriculture
Dept. of Agriculture

1428 S King St.
Honolulu, HI 96814

Land Use Comission
335 Merchant St., Rm. 104
Honolulu, HI 96813

City and County Agencies

The Honorable Jeremy Harris
Acting Mayor, City and County of Honolulu
City Hall
Honolulu, HI 96813

Kauai Regional Library
4344 Hardy Ave.
Lihue, HI 96766

Wailuku Public Library
251 High St.
Wailuku, HI 96793

Kauai County Fire Department
4223 Rice Street
Lihue, HI 96766

Maui County Fire Department
200 Dairy Rd.
Kahului, HI 96732

Environmental Organizations

Ms. Susan E. Miller
Natural Resources Defense Council, Inc.
212 Merchant St., Suite 203
Honolulu, HI 96813

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

Ms. Marjorie F.Y. Ziegler
Sierra Club Legal Defense Fund, Inc.
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Other Interested Parties

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1525 Bernice St.
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Kualapuu, HI 96757

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Kekaha, HI 96752

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Dr. Clifford W. Smith, Editor
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Lawai, HI 96765

Mr. John T. Waterhouse
Probate Dept.
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Hanalei, HI 96714

Ken Wood (*)(**)
National Tropical Botanical Garden
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Lawai, HI 96765

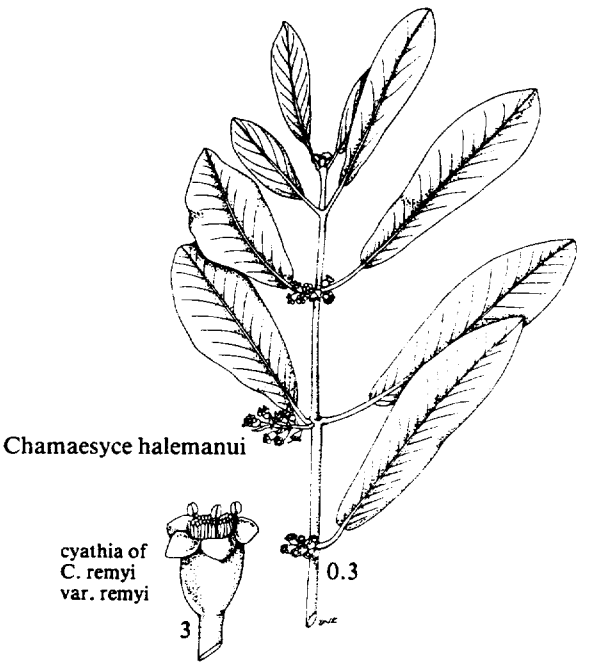
(*) - Comments were received
(**) - Personal communication received

APPENDIX B - LINE DRAWINGS OF PLANTS

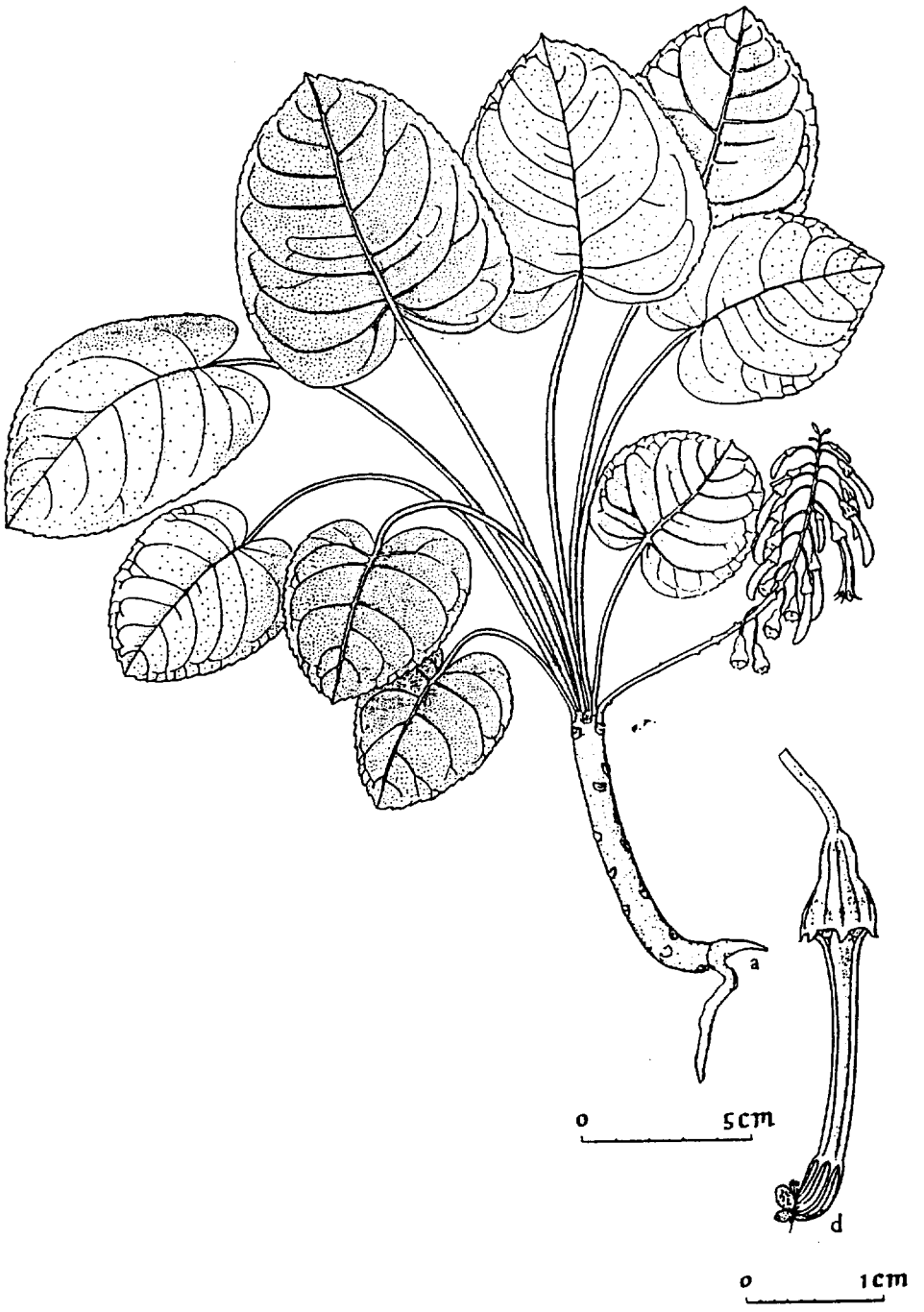
No line drawings were available for the following taxa:

Cyrtandra limahuliensis
Diellia pallida
Hedyotis cookiana
Lipochaeta faurei
Lipochaeta micrantha var. *exigua*
Lysimachia filifolia
Melicope haupuensis
Melicope quadrangularis
Phyllostegia waimeae
Schiedea spergulina var. *leiopoda*
Stenogyne campanulata
Wilkesia hobdyi

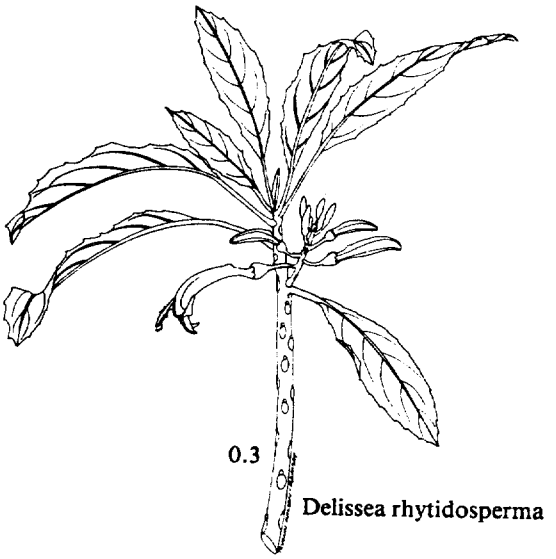
Line drawing of *Brighamia insignis* from St. John (1969b).



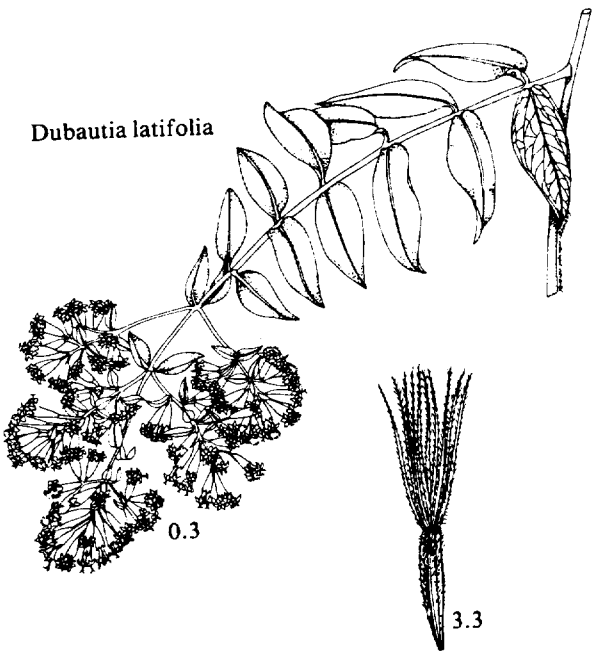
Line drawing of *Chamaesyce halemanui* from Wagner et al. (1990).



Line drawing of *Cyanea asarifolia* from St. John (1975).

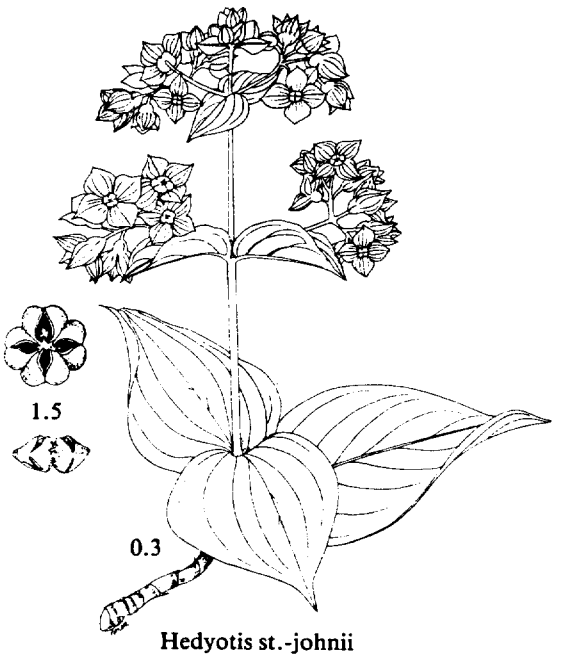


Line drawing of *Delissea rhytidosperma* from Wagner et al. (1990).



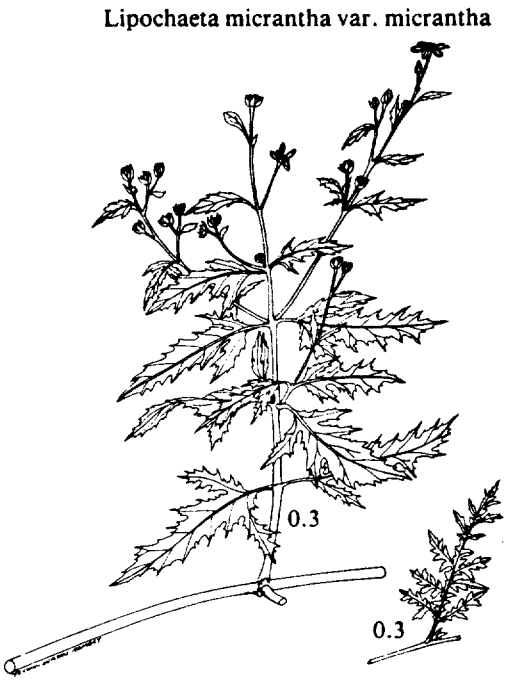
Line drawing of *Dubautia latifolia* from Wagner et al. (1990).

Line drawing of *Exocarpos luteolus* from Degener (1932b).



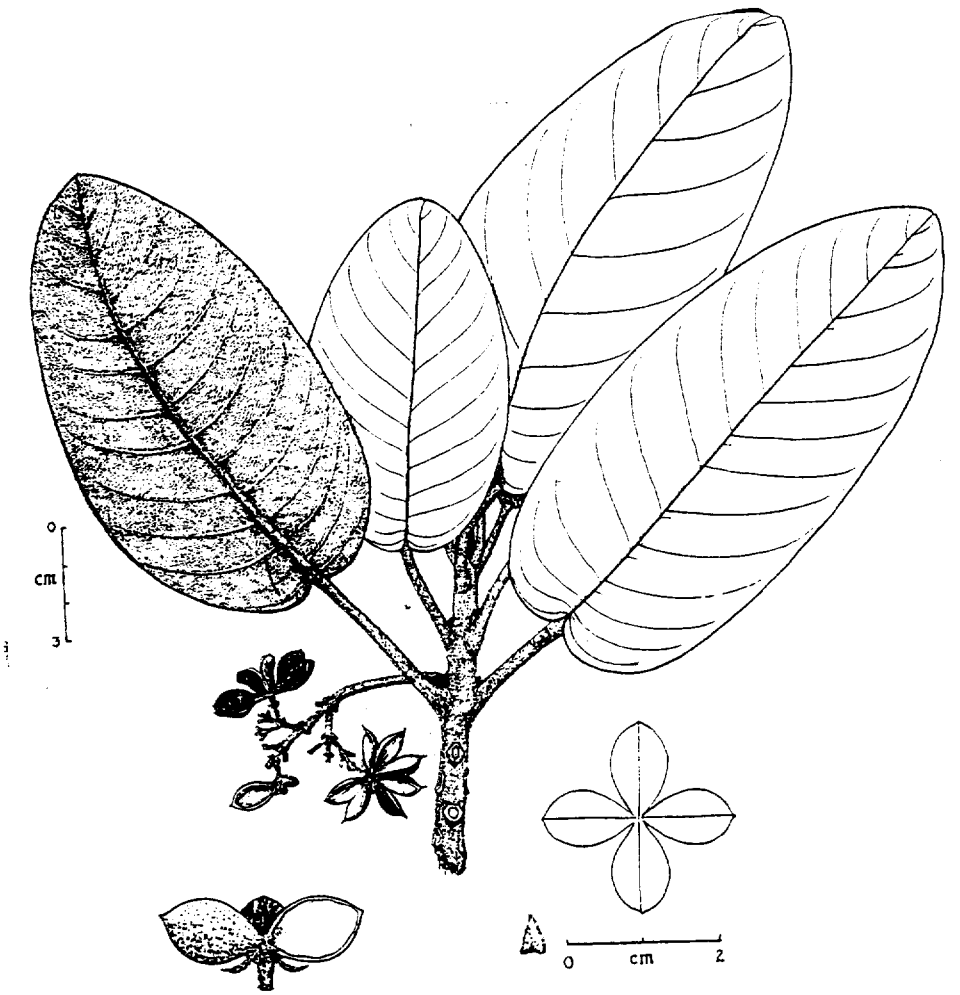
Line drawing of *Hedyotis st.-johnii* from Wagner et al. (1990).

Line drawing of *Hibiscus clayi* from Degener (1932b).

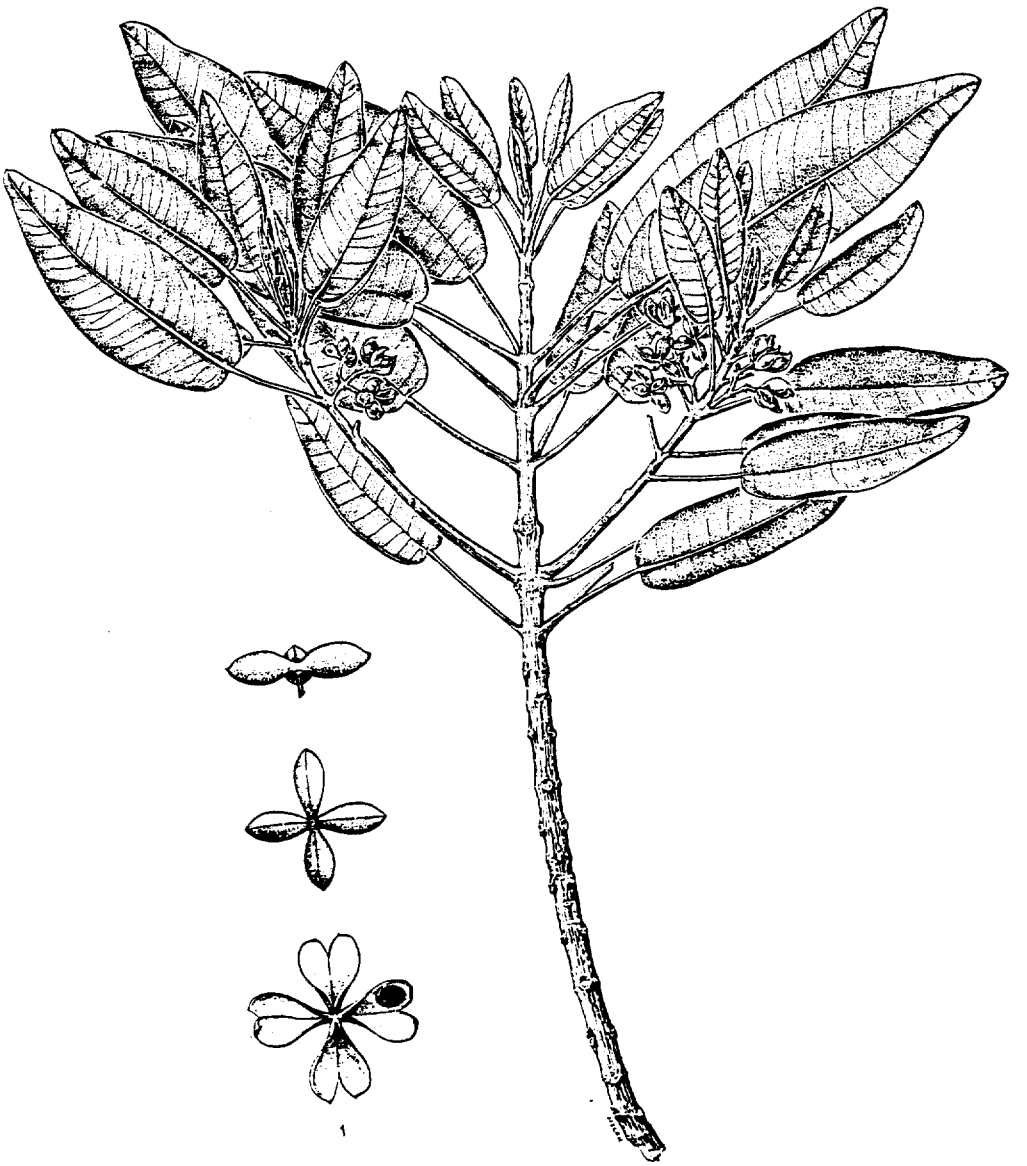


Line drawing of *Lipochaeta micrantha* var. *micrantha* from Wagner et al. (1990).

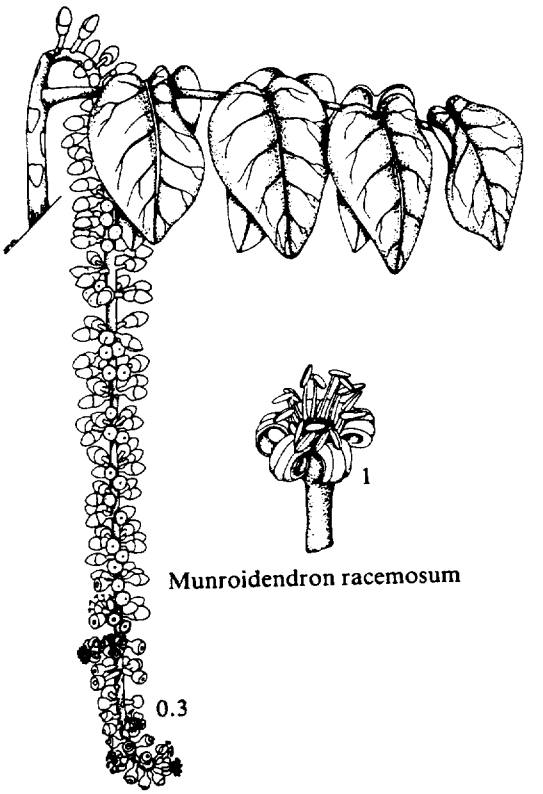
Line drawing of *Lipochaeta waimeaensis* from St. John (1972).



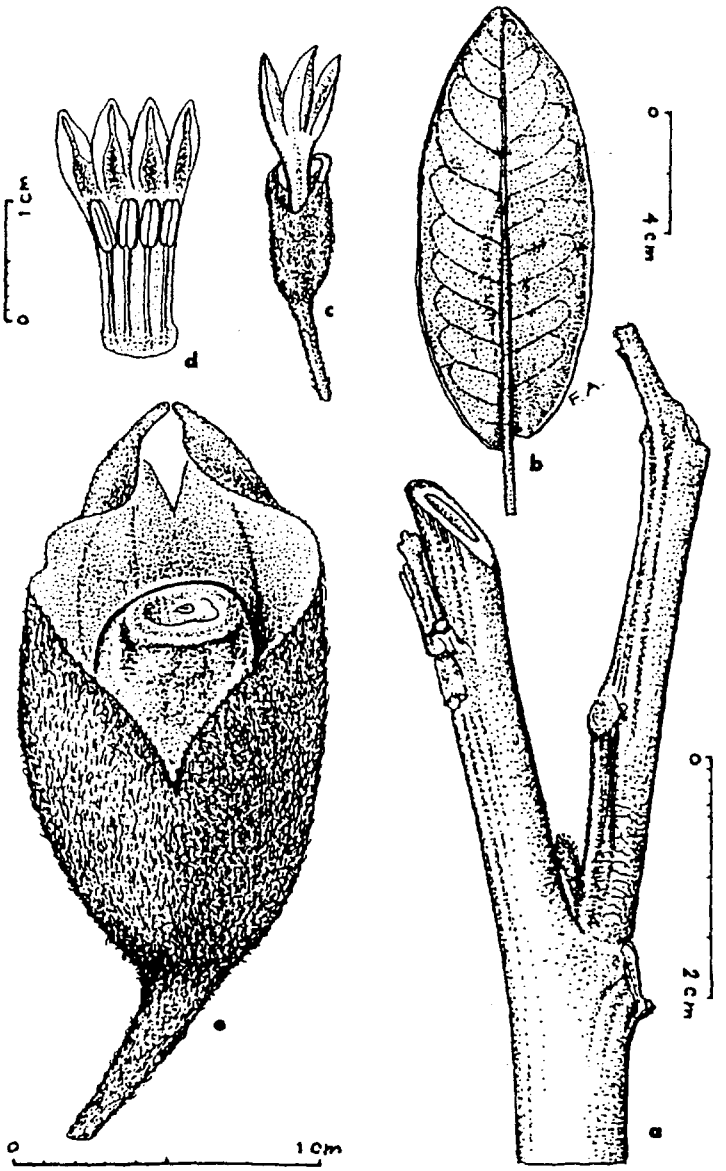
Line drawing of *Melicope knudsenii* (formerly *Pelea multiflora*) from Degener et al. (1962b).



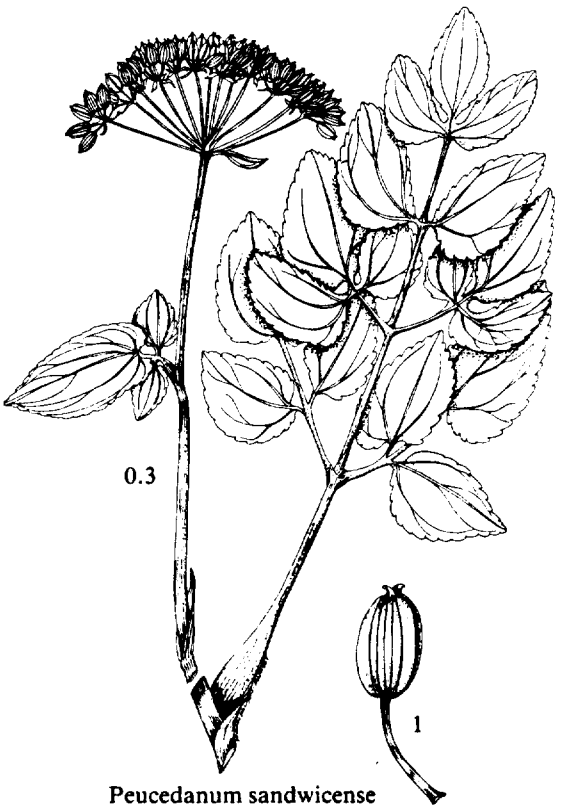
Line drawing of *Melicope pallida* (formerly *Pelea pallida*) from Degener et al. (1960).



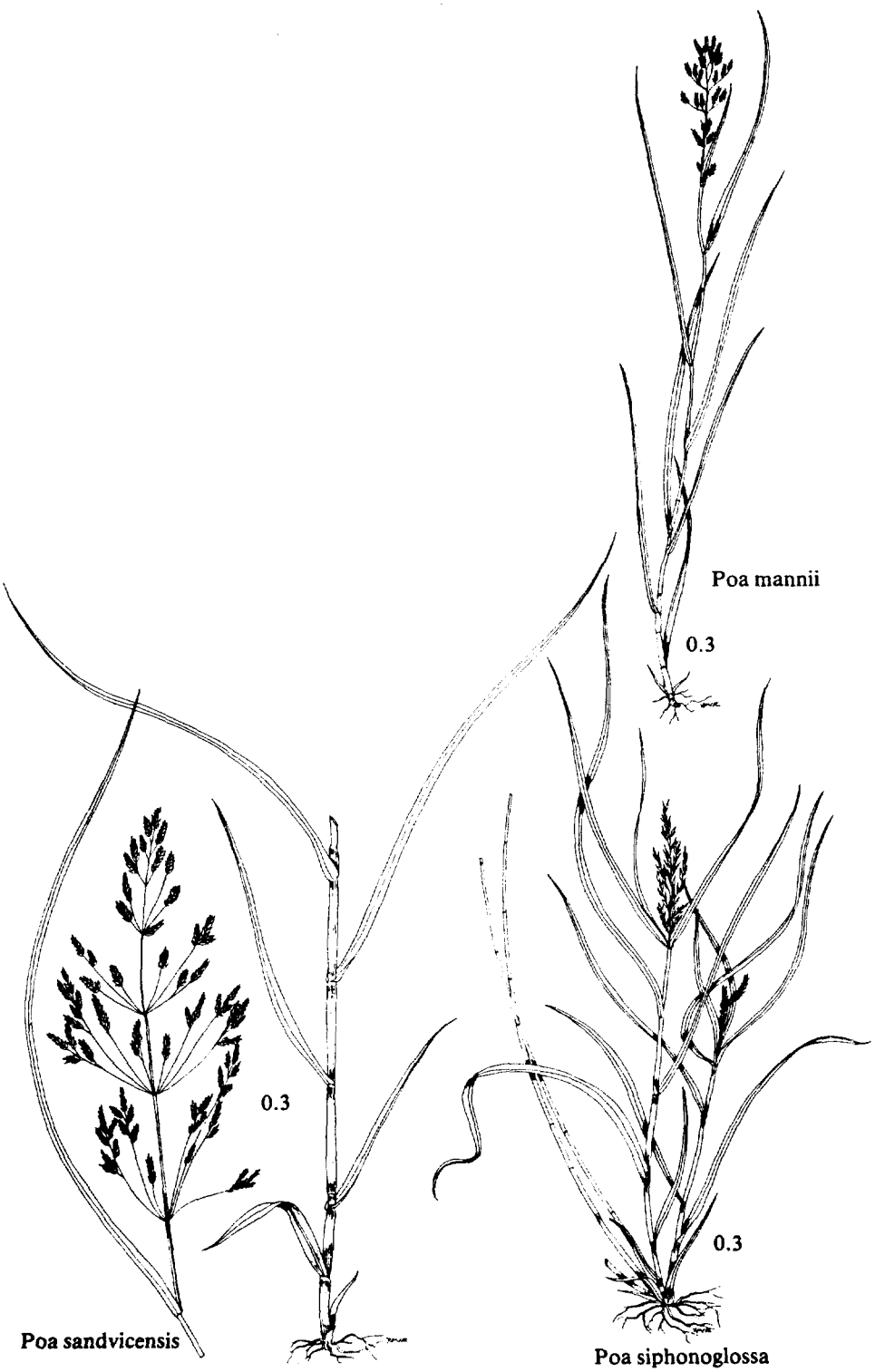
Line drawing of *Munroidendron racemosum* from Wagner et al. (1990).



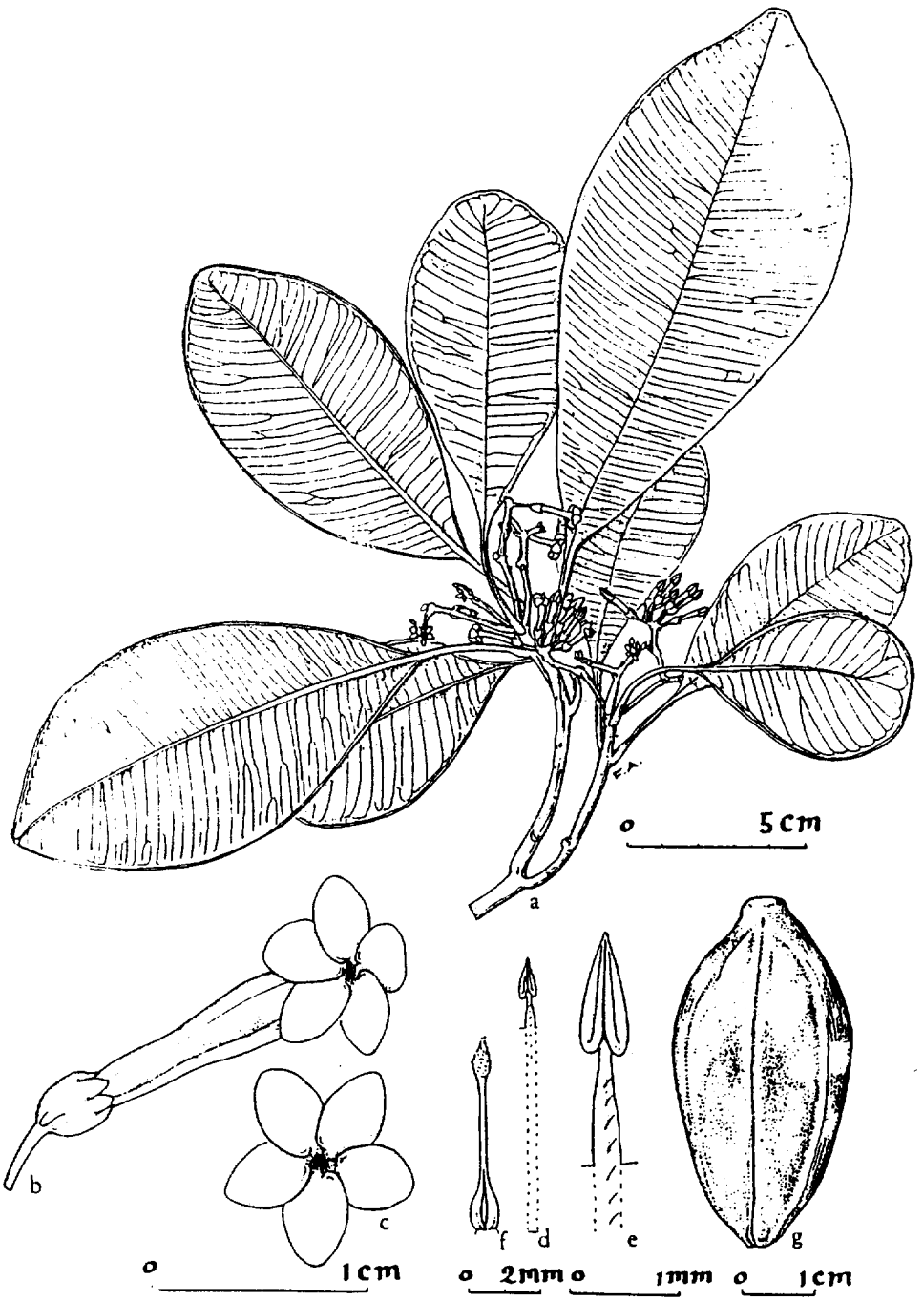
Line drawing of *Nothocestrum peltatum* (formerly *Nothocestrum inconcinnum*) from St. John (1986).



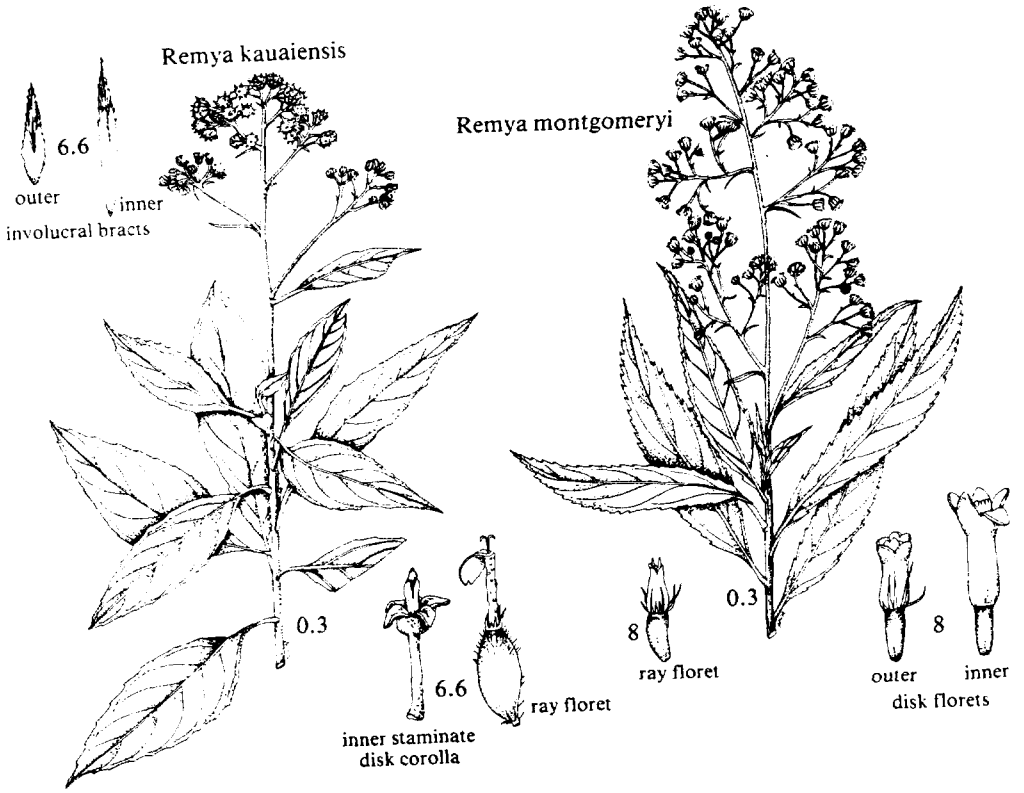
Line drawing of *Peucedanum sandwicense* from Wagner et al. (1990).



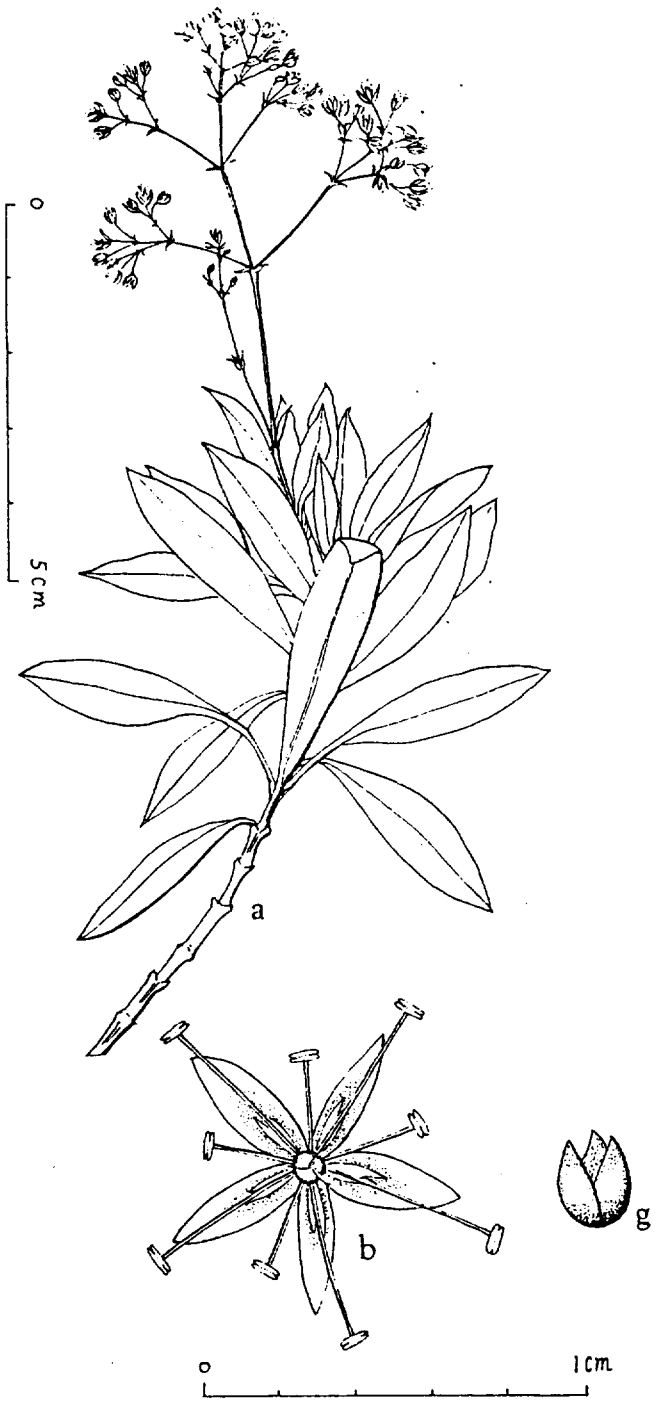
Line drawings of *Poa mannii*, *Poa sandvicensis* and *Poa siphonoglossa* from Wagner et al. (1990).



Line drawing of *Pteralyxia kauaiensis* (formerly *Pteralyxia elliptica*) from St. John (1981).



Line drawings of *Remya kauaiensis* and *Remya montgomeryi* from Wagner et al. (1990).



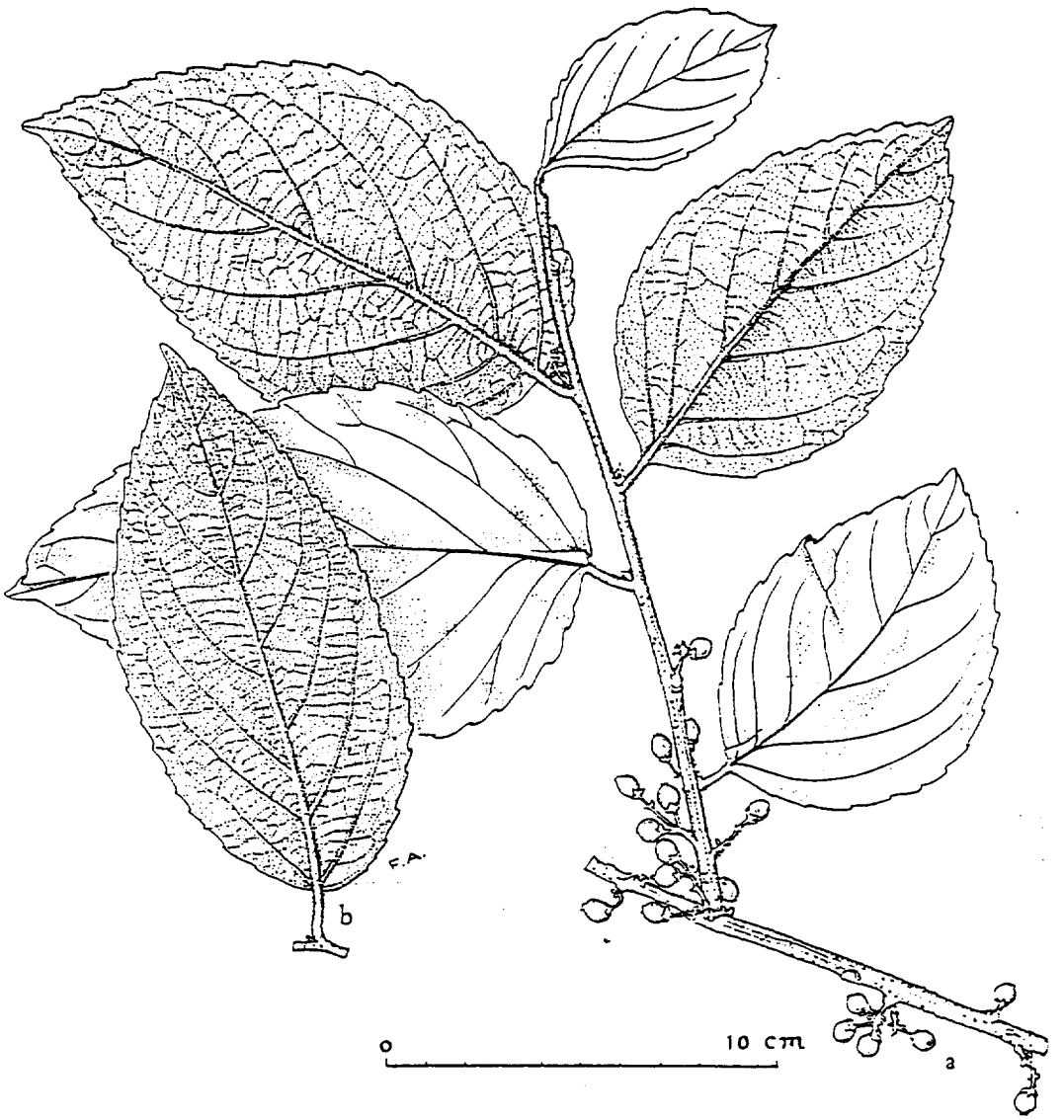
Line drawing of *Schiedea apokremnos* from St. John (1970).

Schiedea spergulina var. spergulina

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

Solanum sandwicense

Line drawing of *Solanum sandwicense* from Wagner et al. (1990).



Line drawing of *Xylosma crenatum* (formerly *Antidesma crenatum*) from St. John (1972).

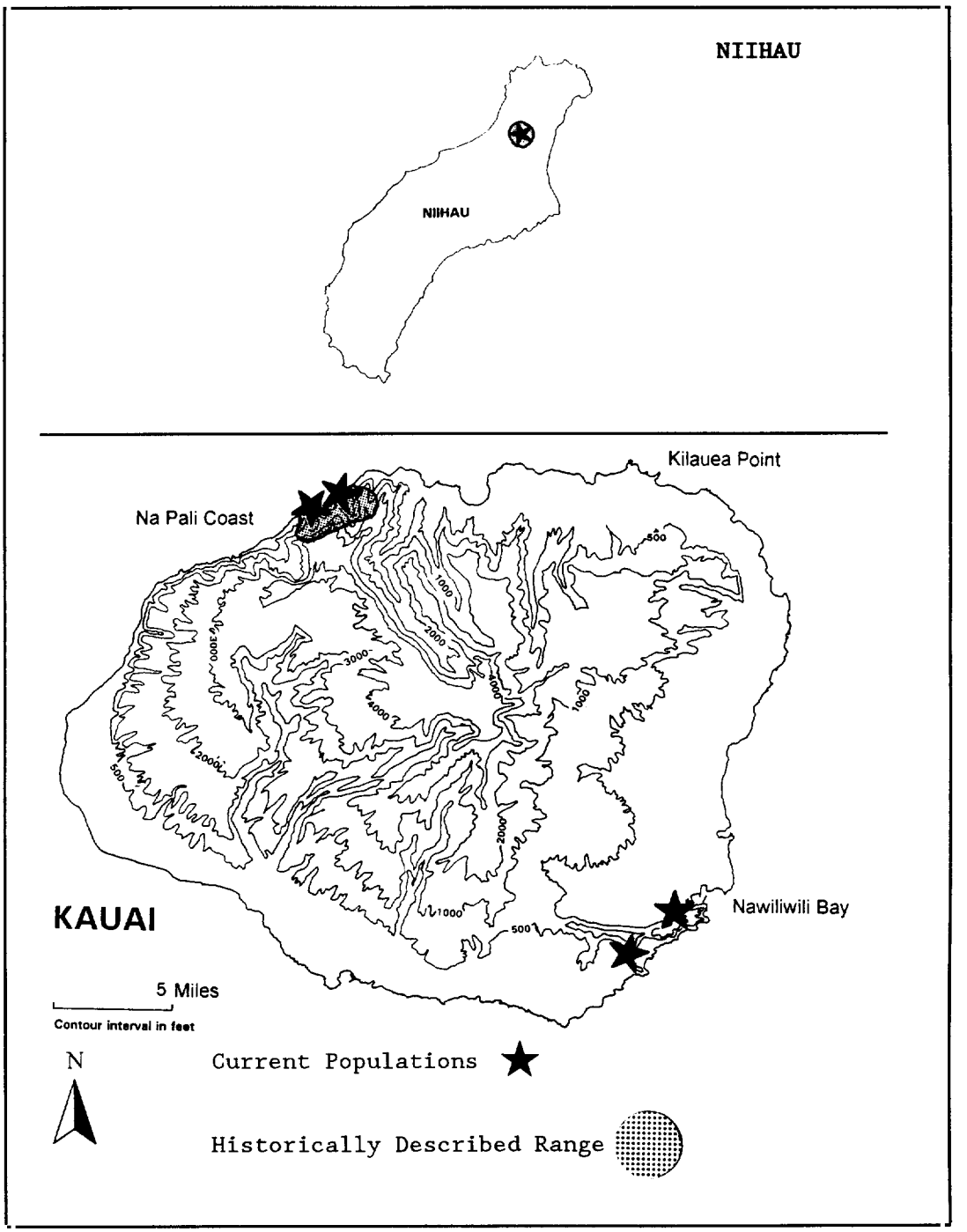
APPENDIX C - MAPS OF HISTORIC AND CURRENT RANGE

Explanation of Key

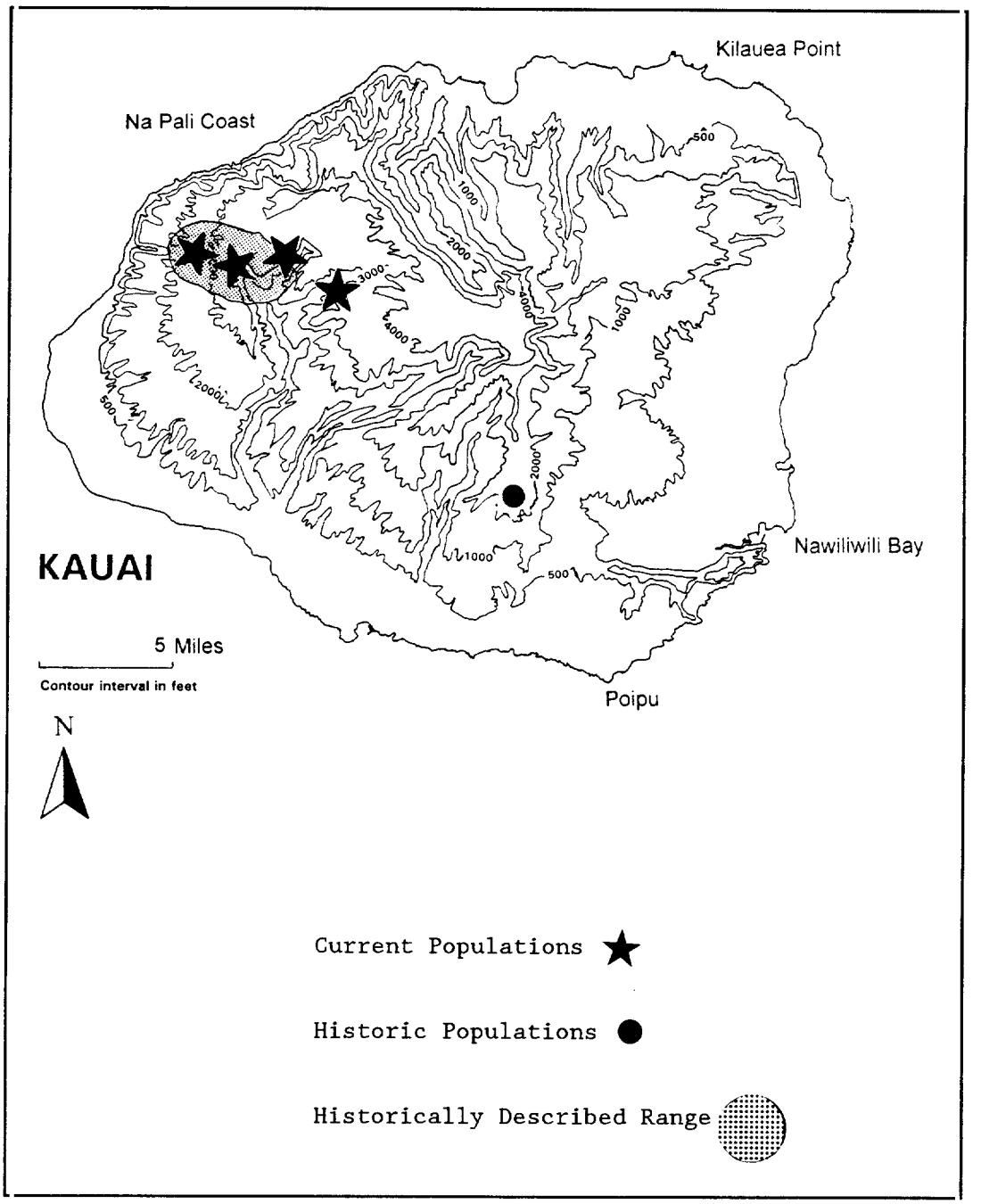
Current populations are those which have been observed within the past 20 years (since 1975). The mapped locations of current populations are primarily from the Hawaii Heritage Program database (HHP 1994). Recently discovered populations, not yet incorporated into the database, have been added to the maps based on descriptions from knowledgeable individuals.

Historic populations are those which have been observed prior to 1975. The mapped locations of historic populations are from the Hawaii Heritage Program database (HHP 1994).

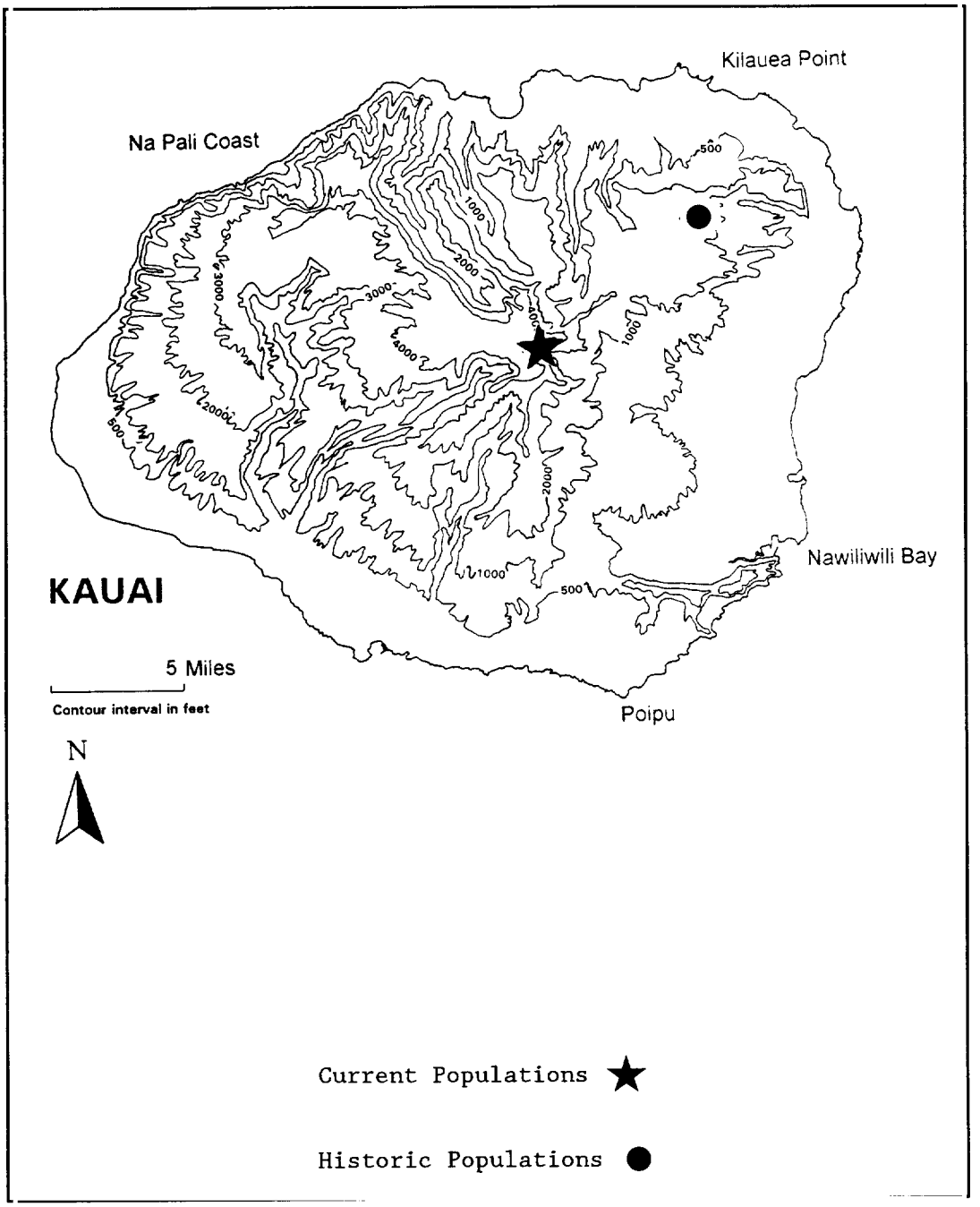
Historically described range has been estimated and drawn onto the map when the historical records describe the general range of a taxon. This is only an estimate of the actual historic range which is impossible to ascertain in nearly all cases.



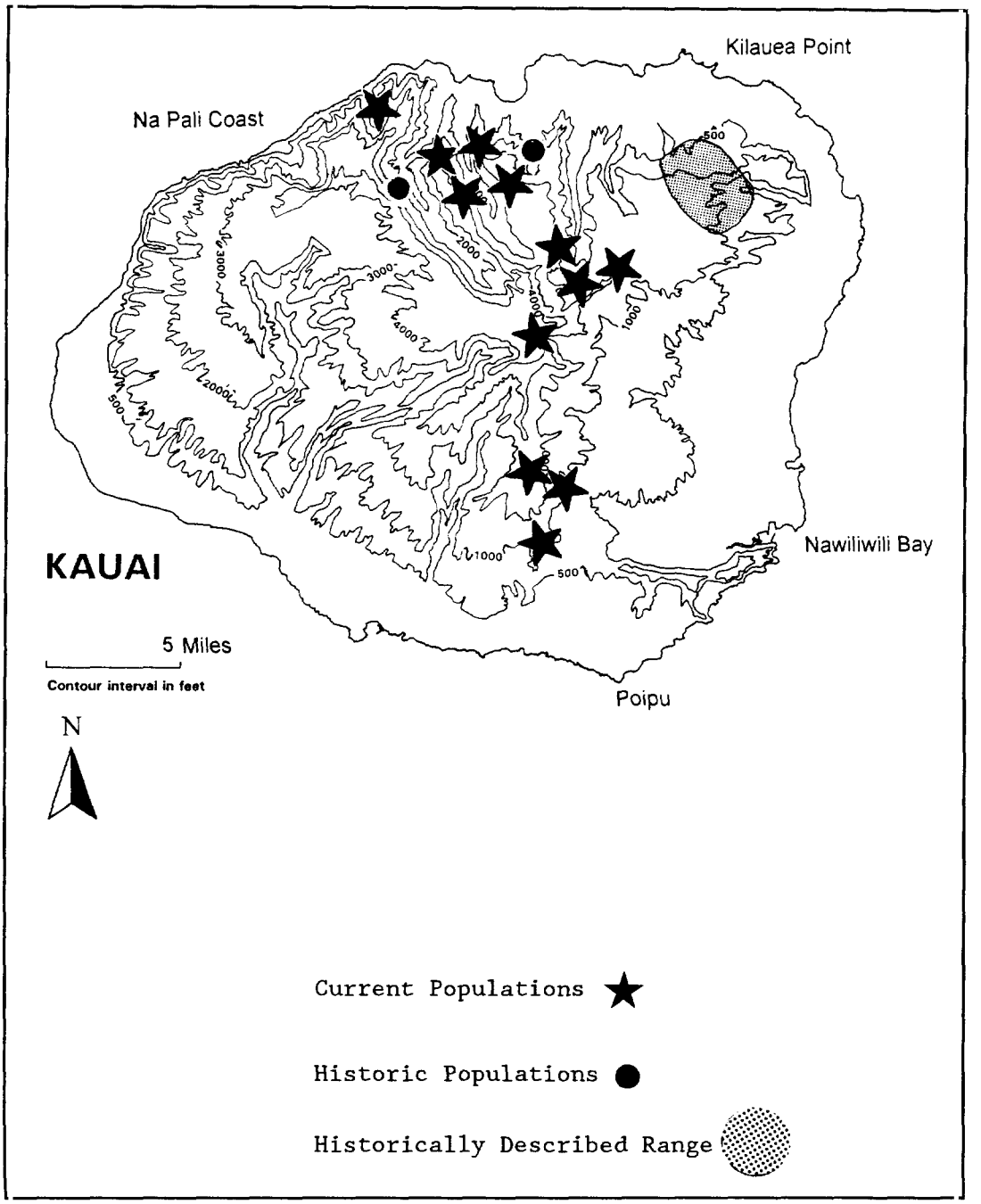
Current and Historic Range of *Brighamia insignis*



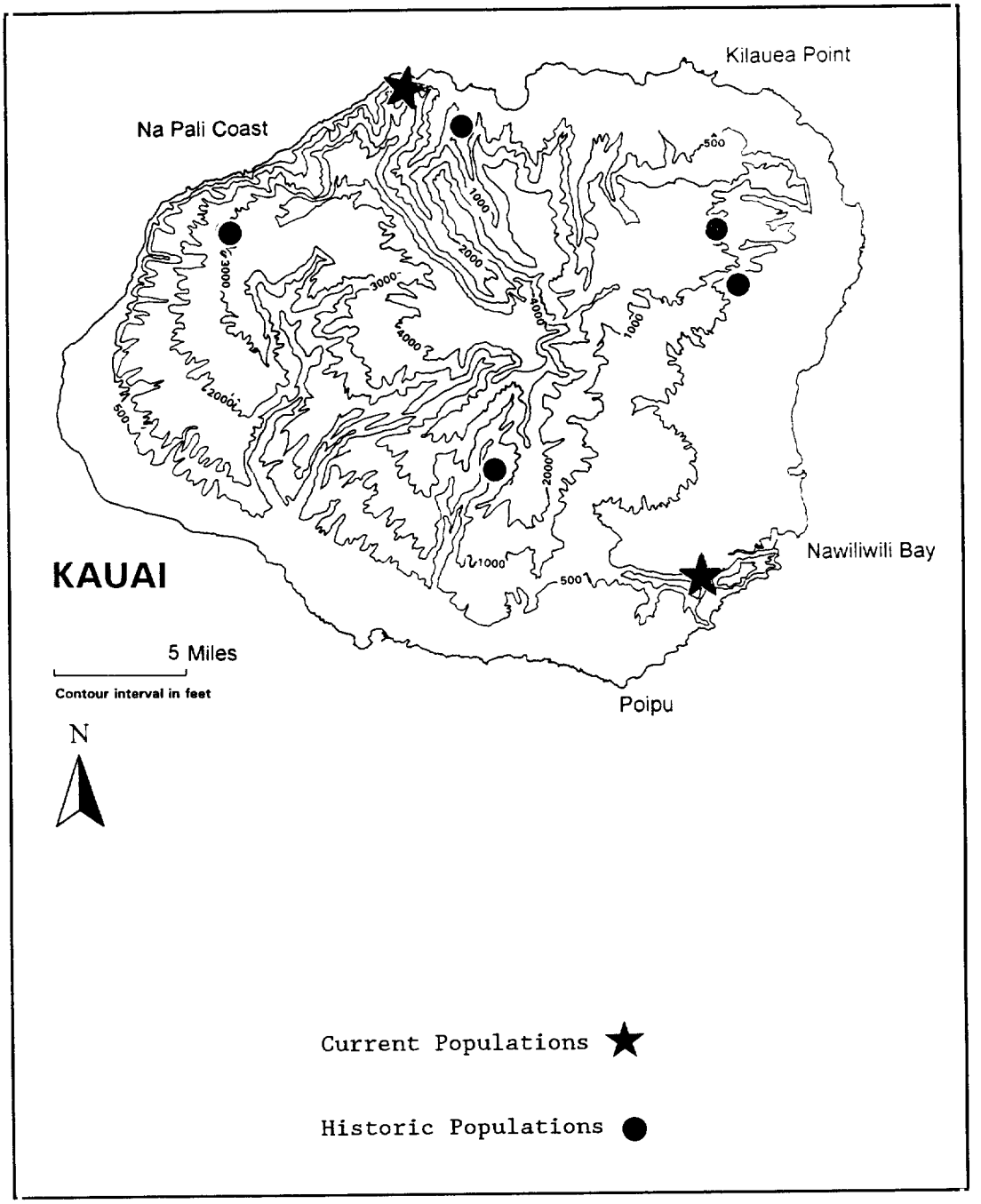
Current and Historic Range of *Chamaesyce halemanui*



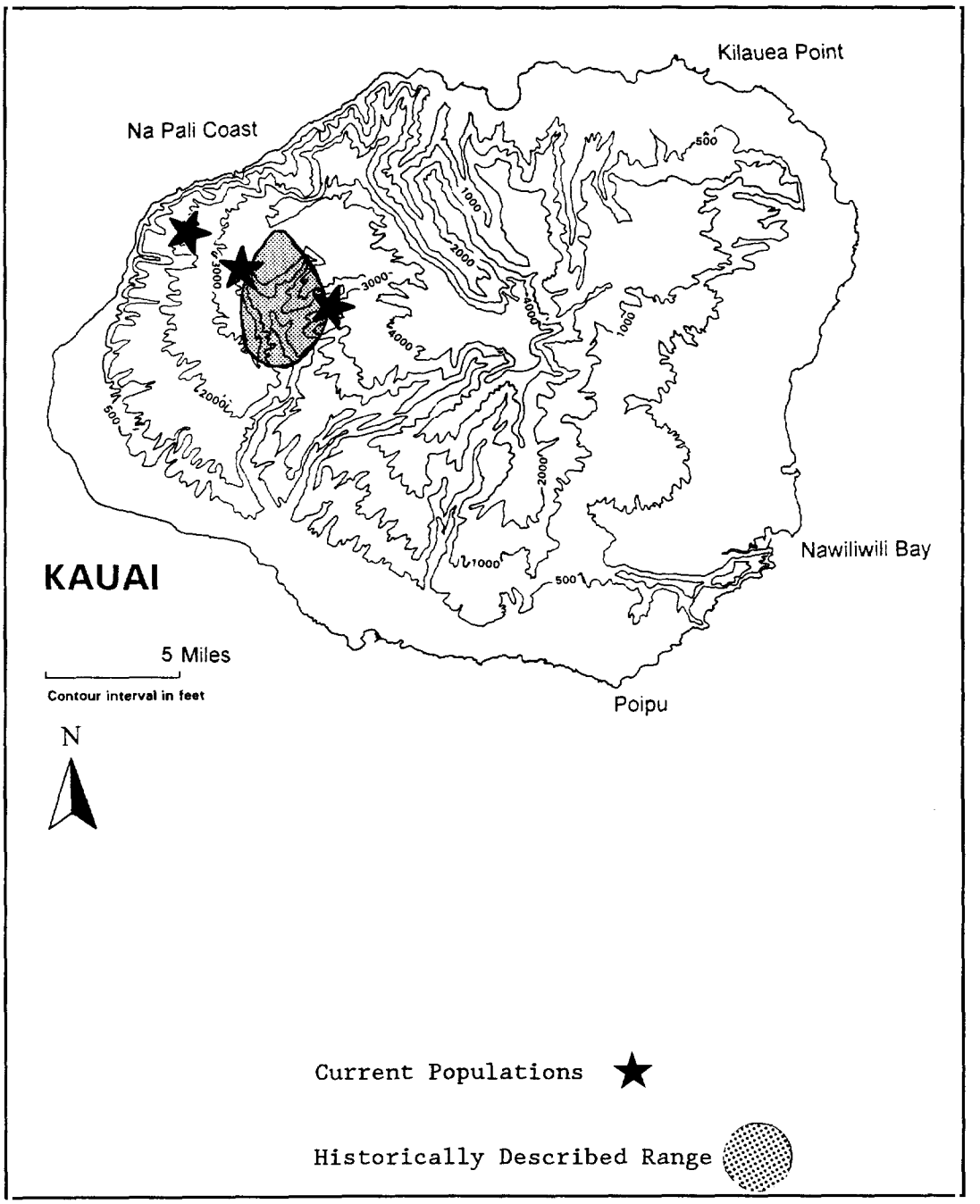
Current and Historic Range of *Cyanea asarifolia*



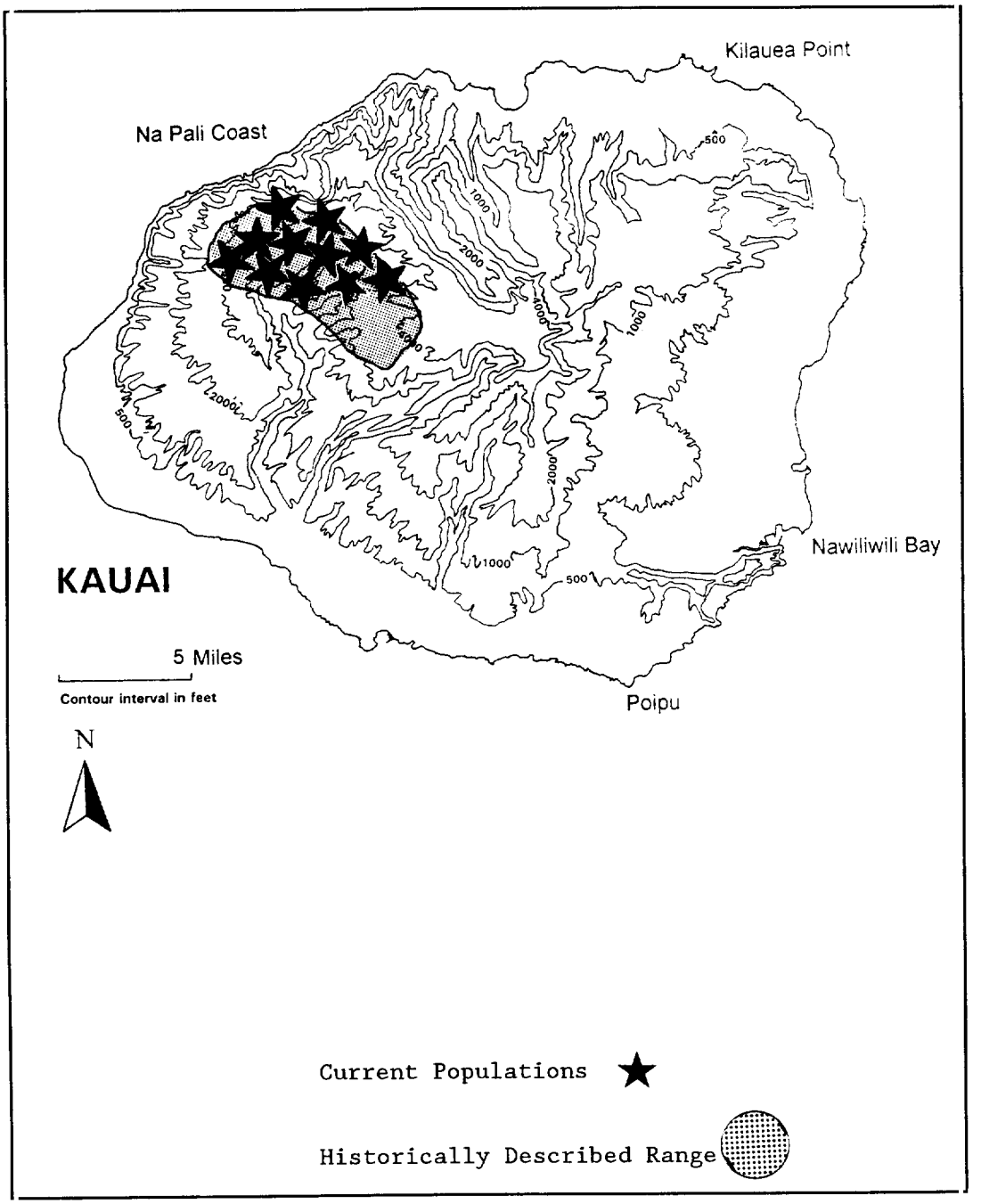
Current and Historic Range of *Cyrtandra limahuliensis*



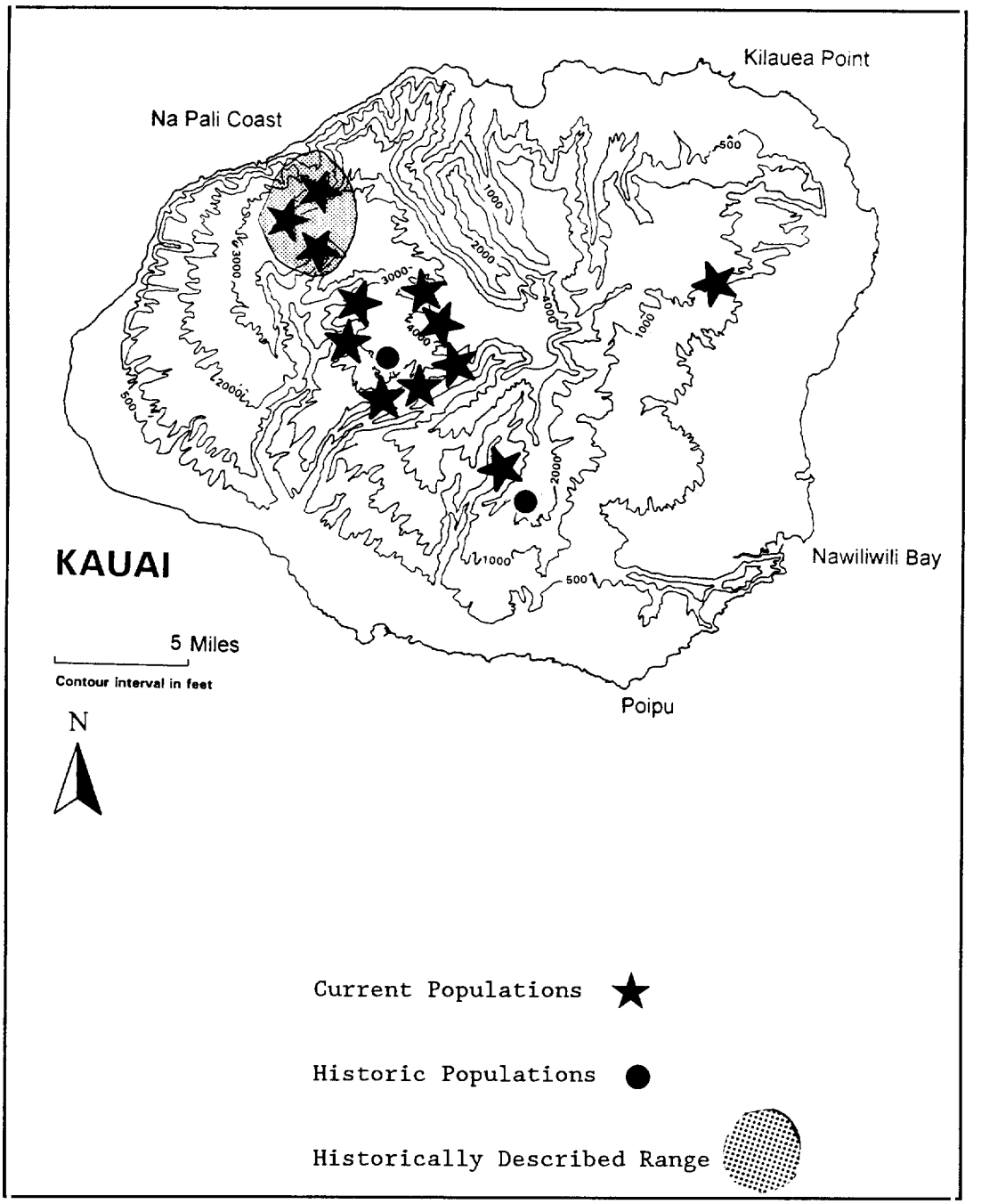
Current and Historic Range of *Delissea rhytidosperma*



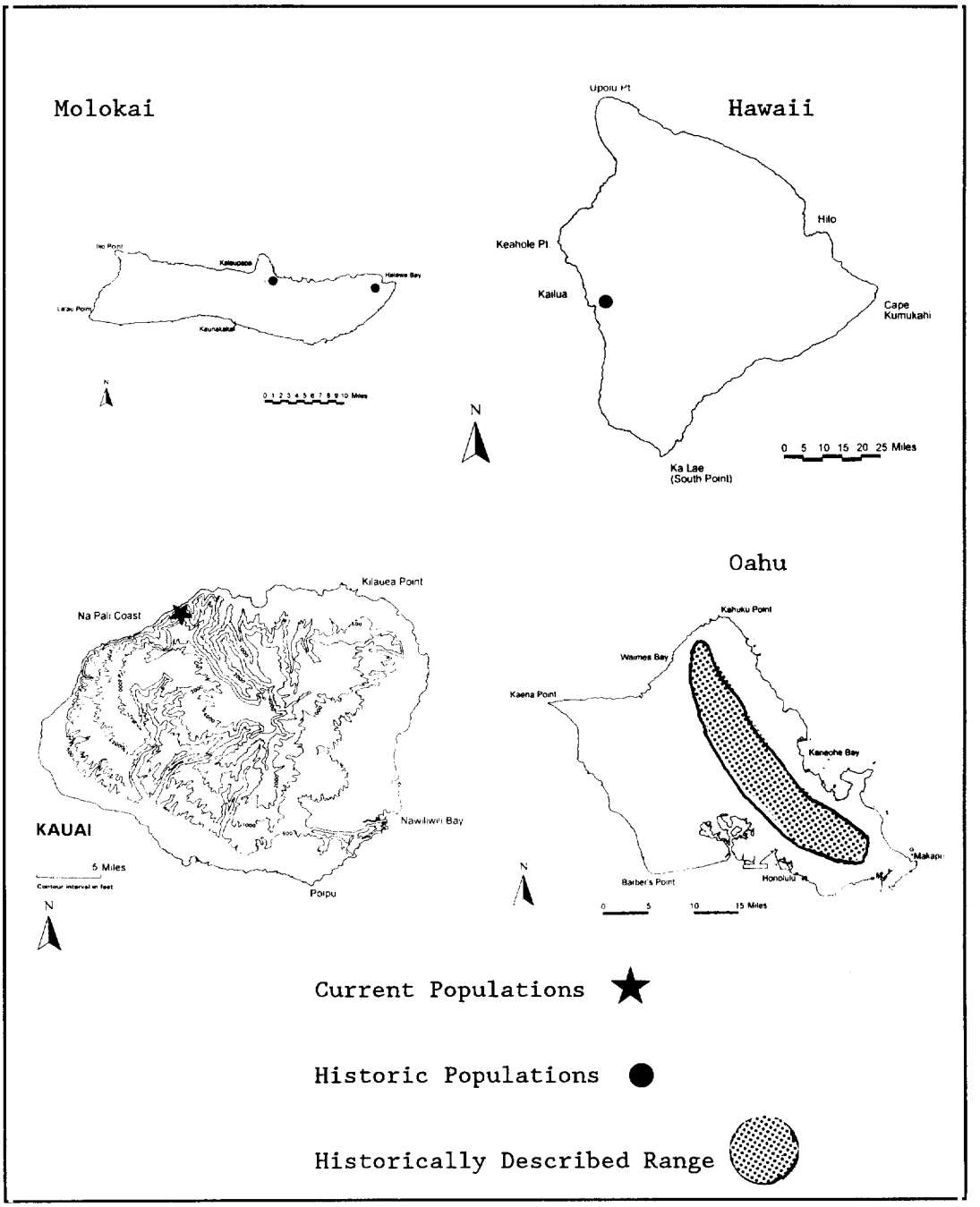
Current and Historic Range of *Diellia pallida*



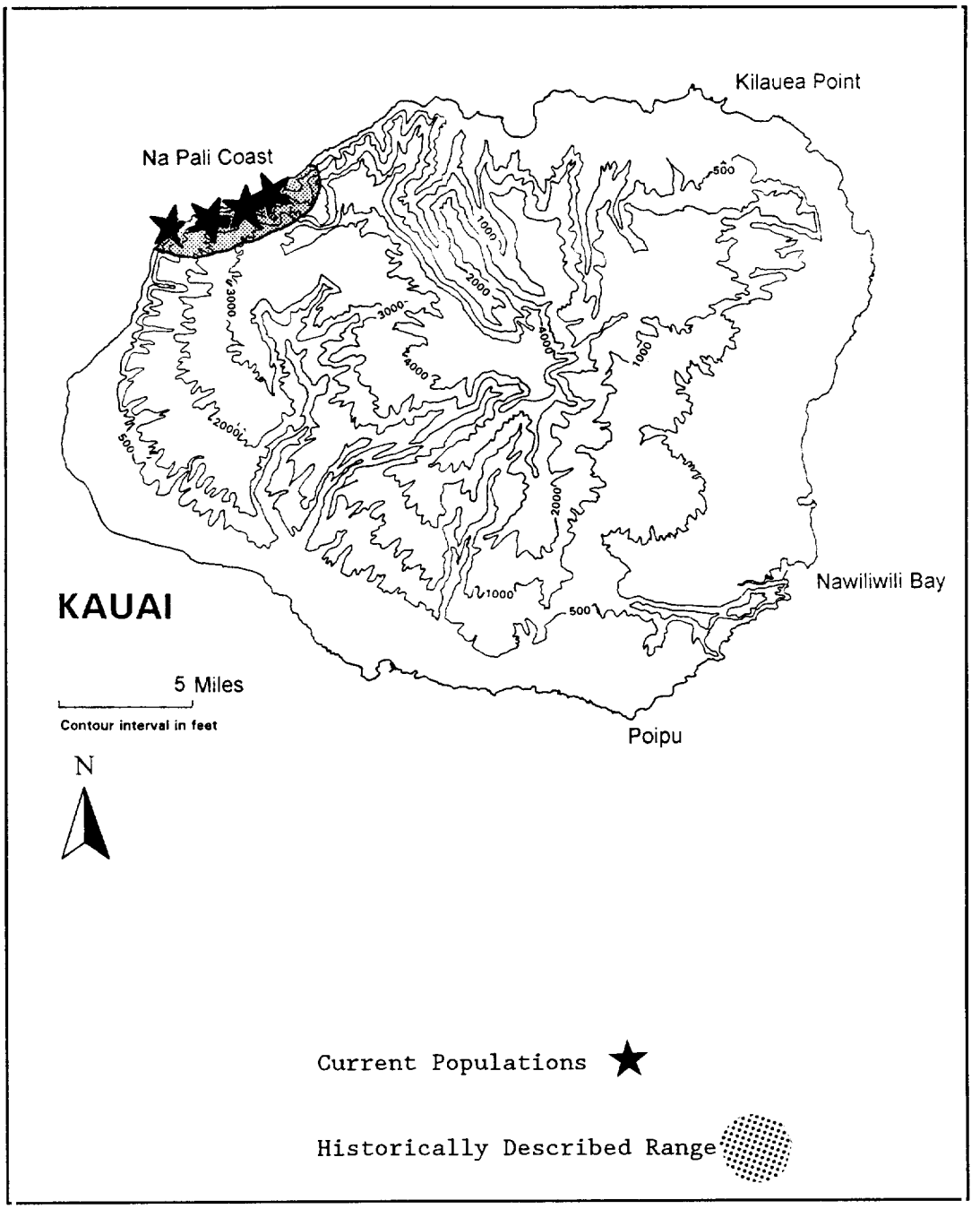
Current and Historic Range of *Dubautia latifolia*



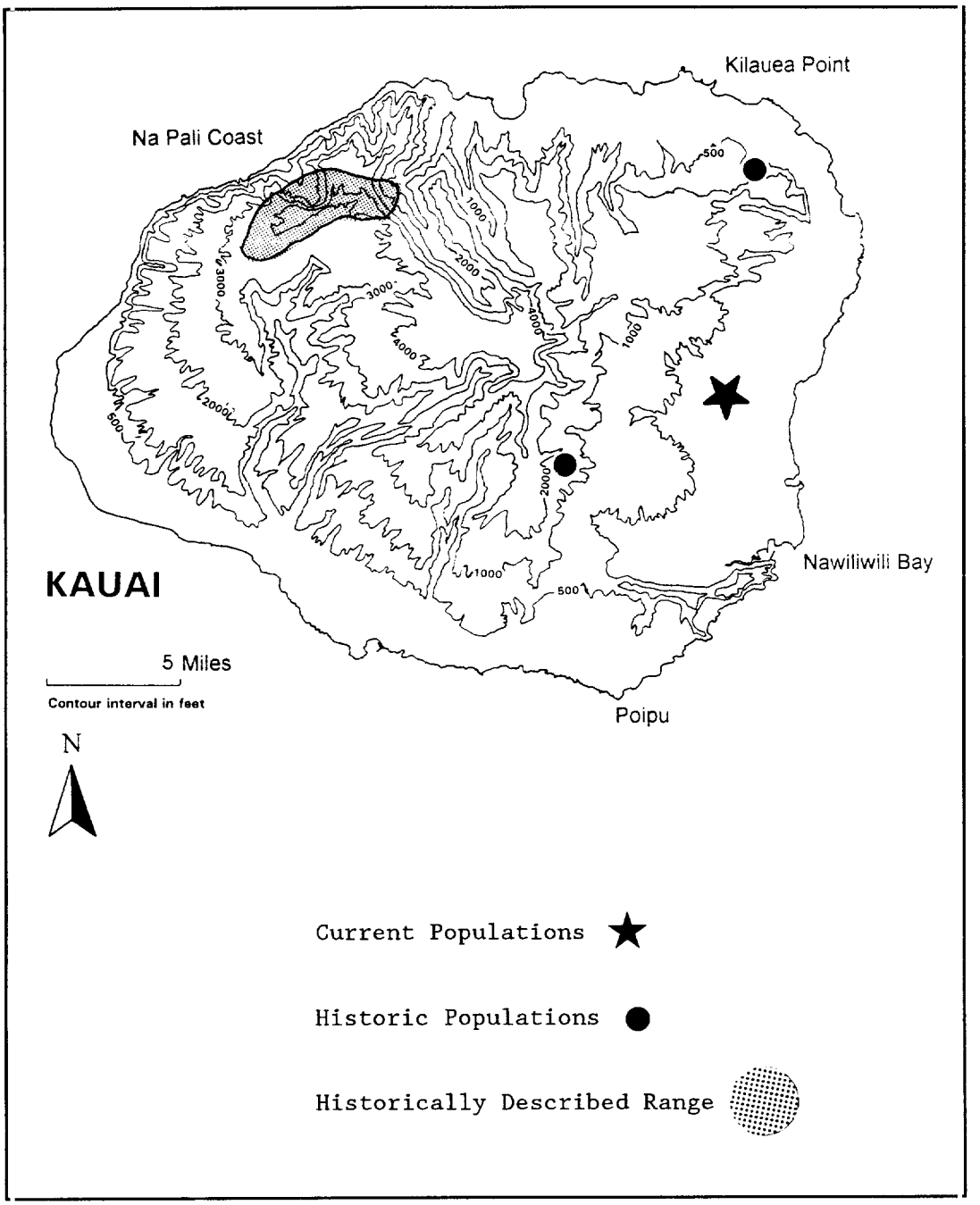
Current and Historic Range of *Exocarpos luteolus*



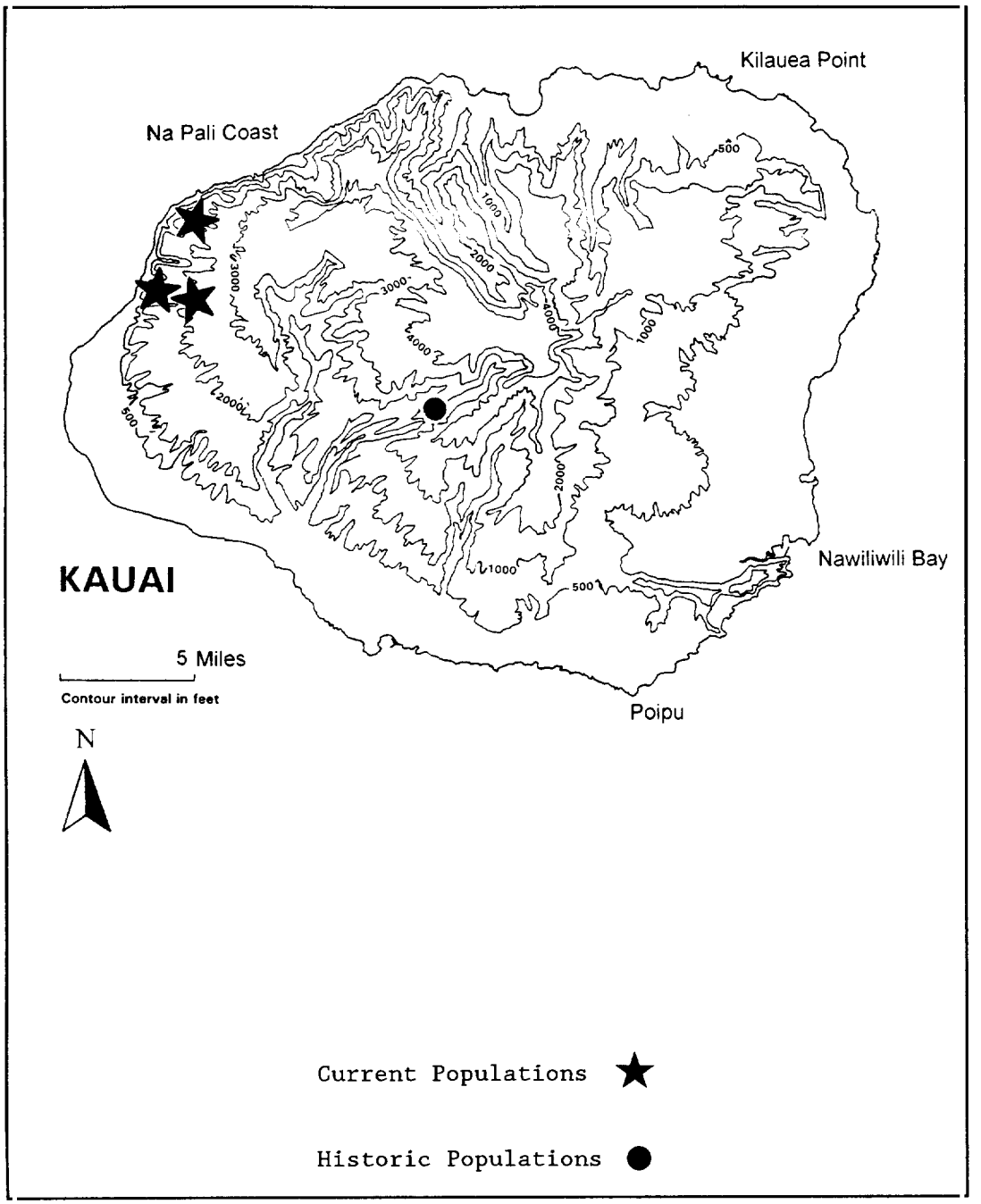
Current and Historic Range of *Hedyotis cookiana*



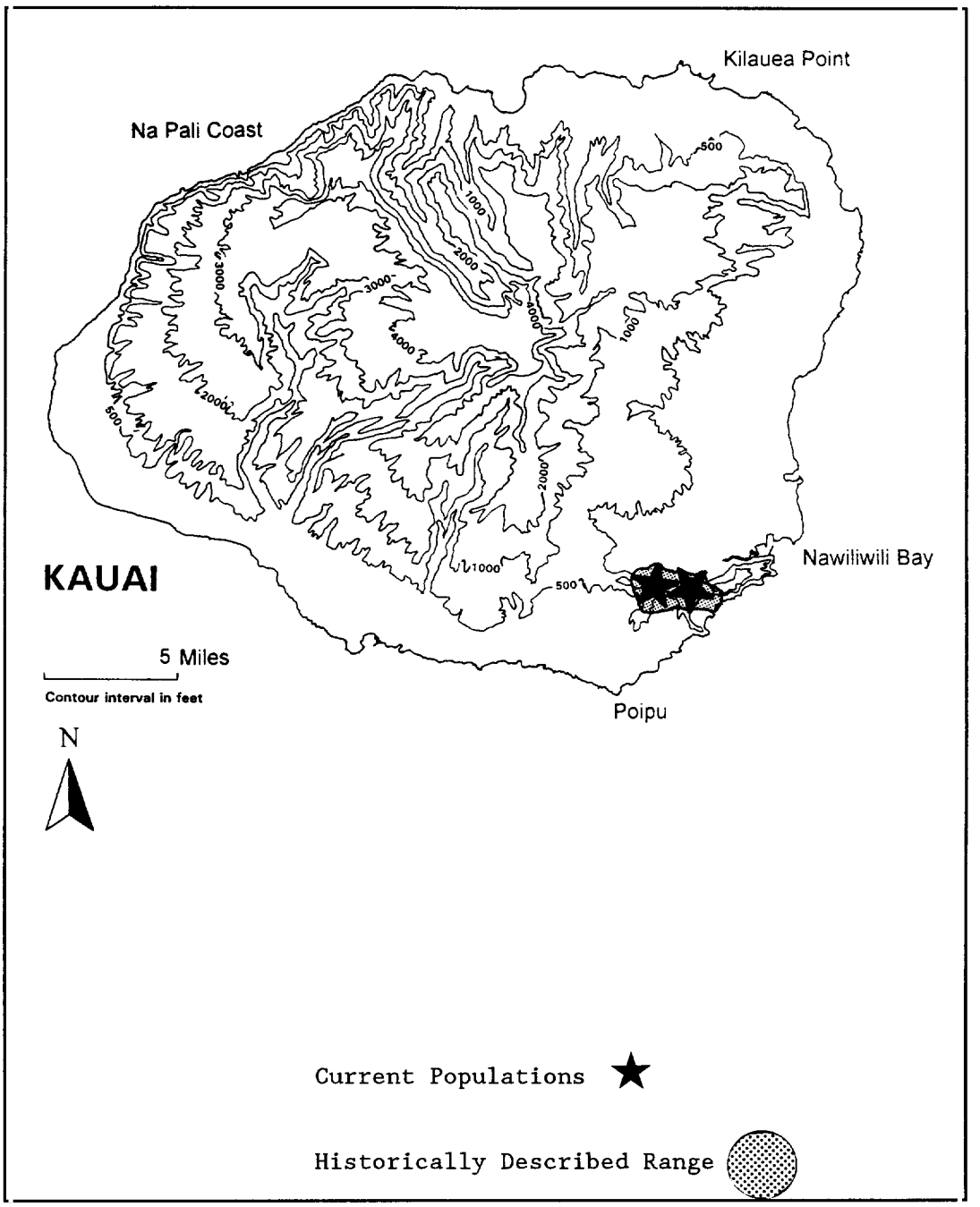
Current and Historic Range of *Hedyotis st.-johni*



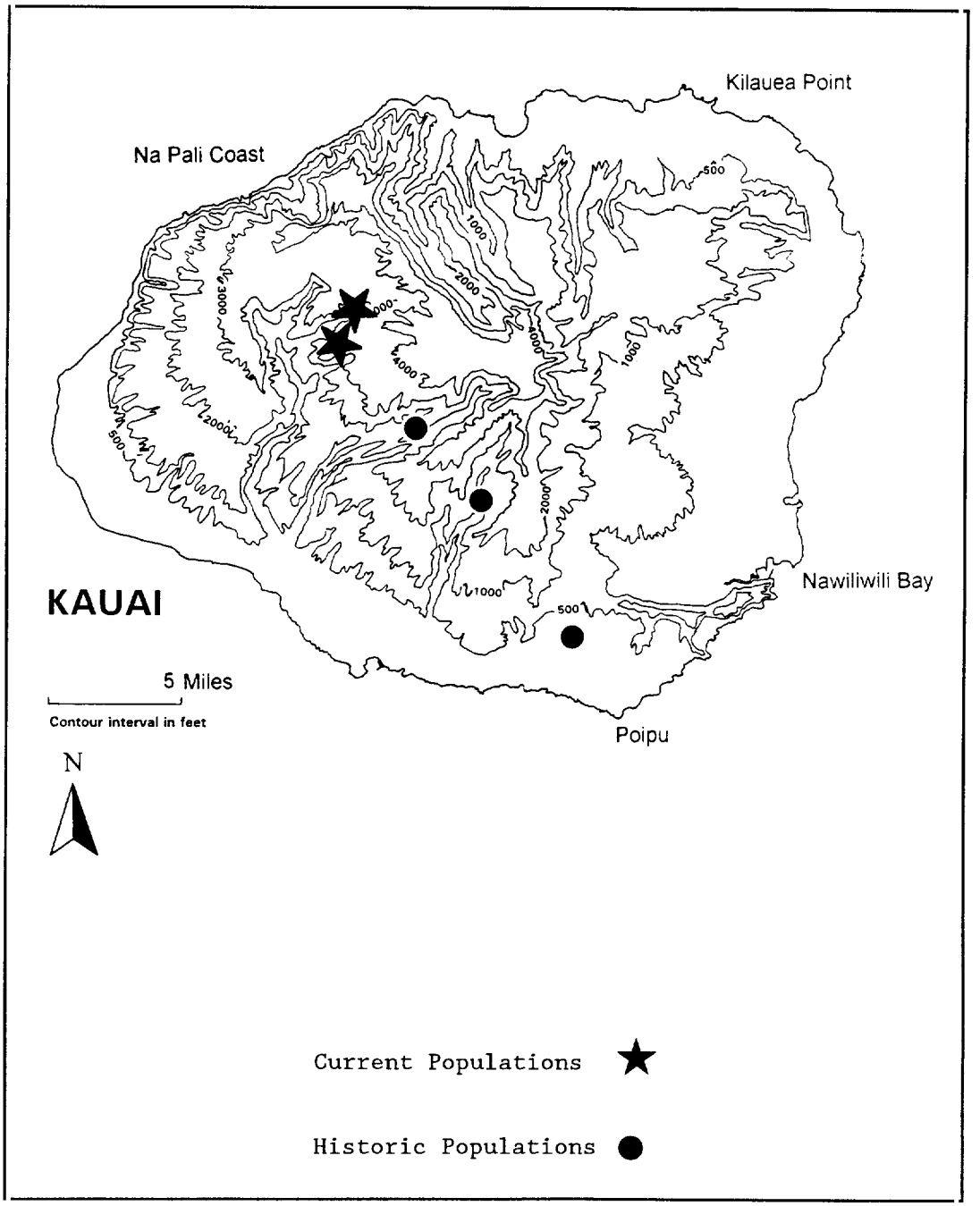
Current and Historic Range of *Hibiscus clayi*



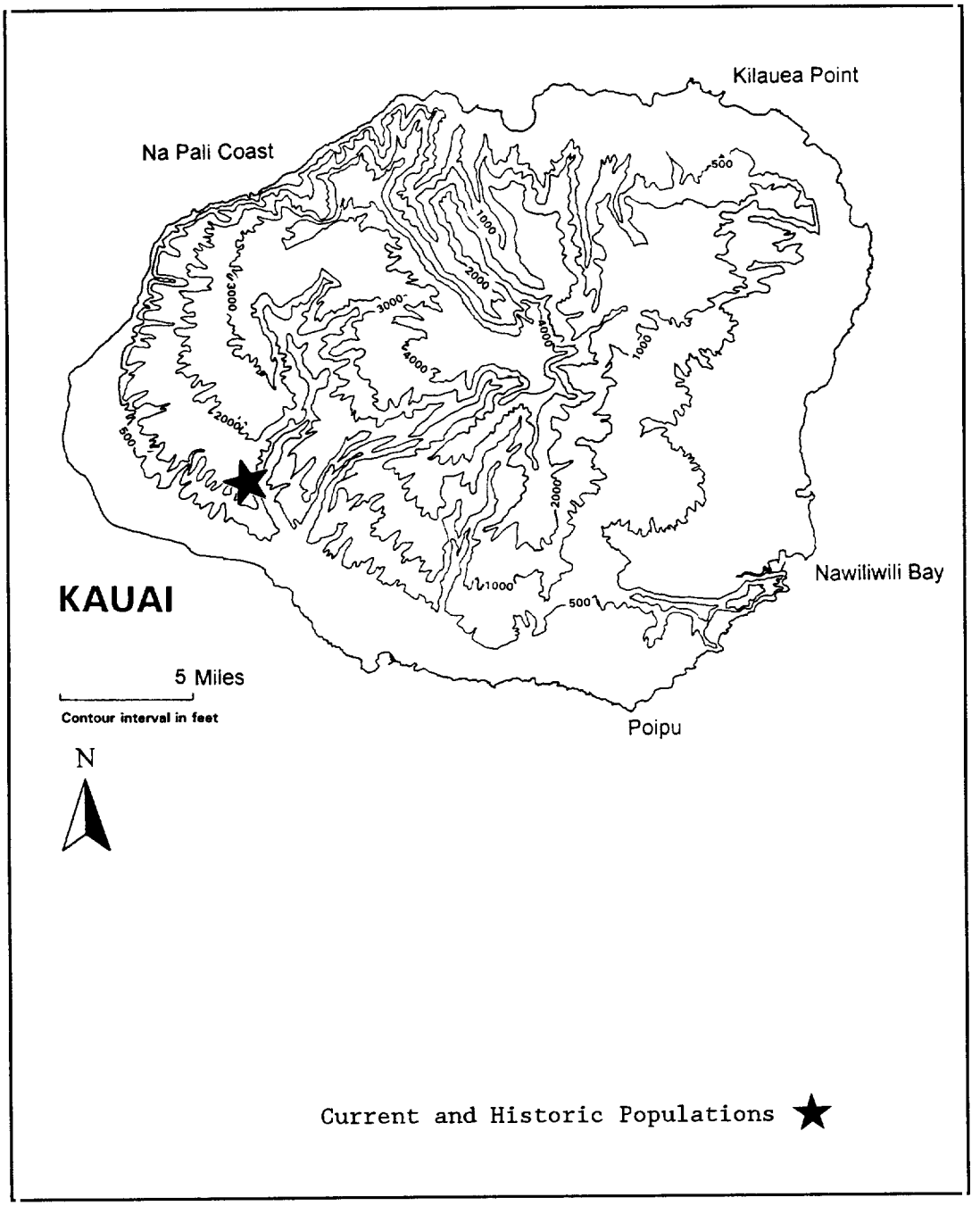
Current and Historic Range of *Lipochaeta fauriei*



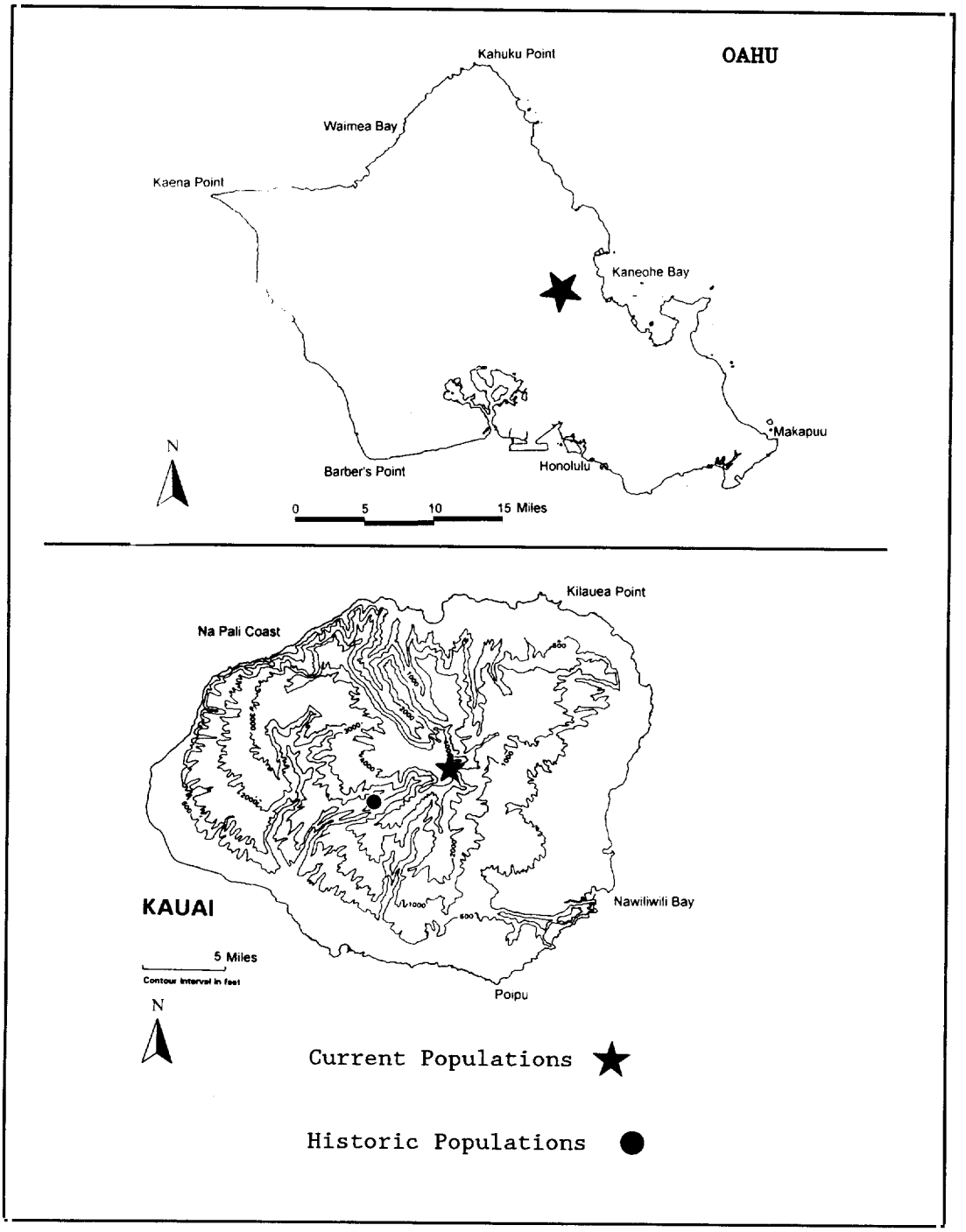
Current and Historic Range of *Lipochaeta micrantha* var. *exigua*



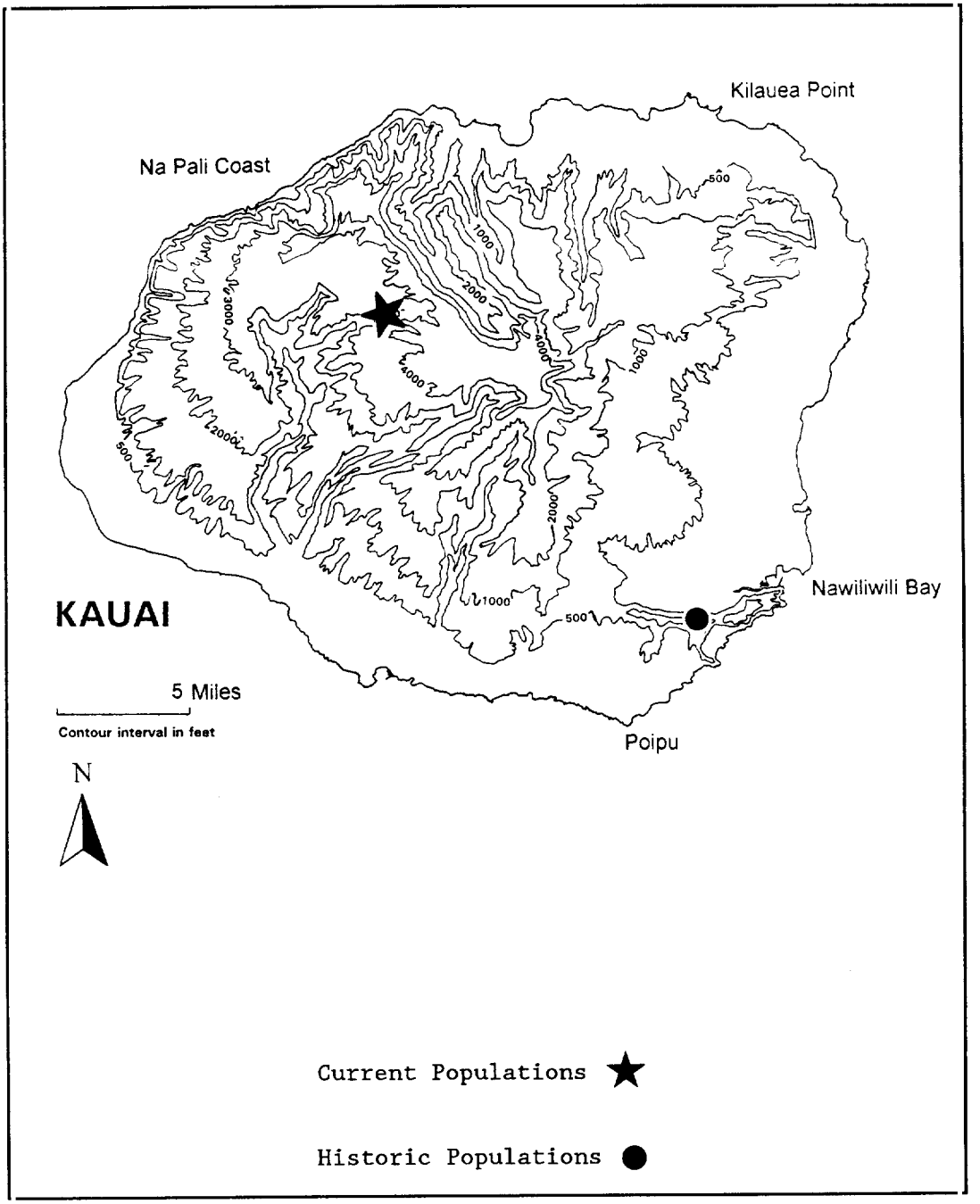
Current and Historic Range of *Lipochaeta micrantha* var. *micrantha*



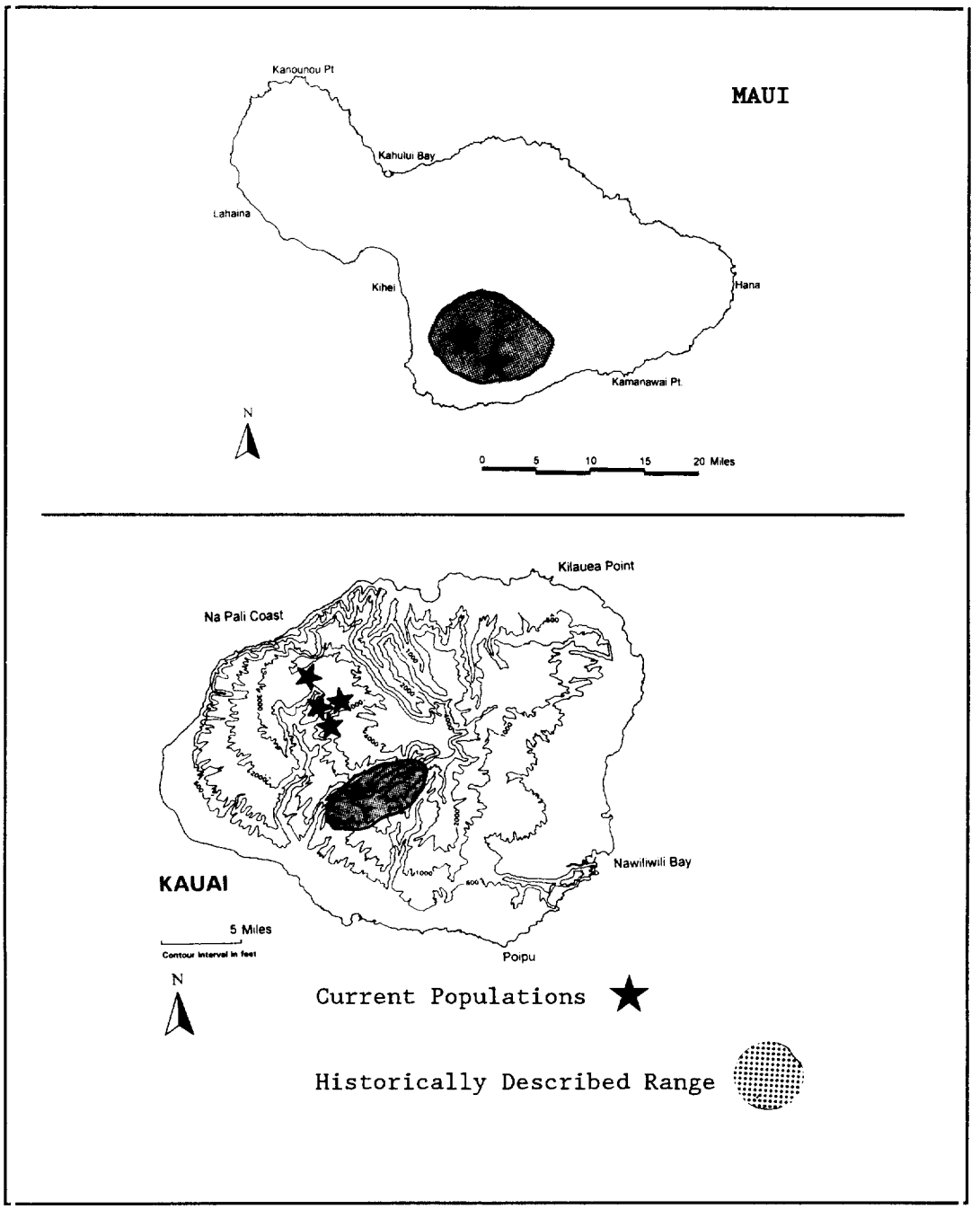
Current and Historic Range of *Lipochaeta waimeaensis*



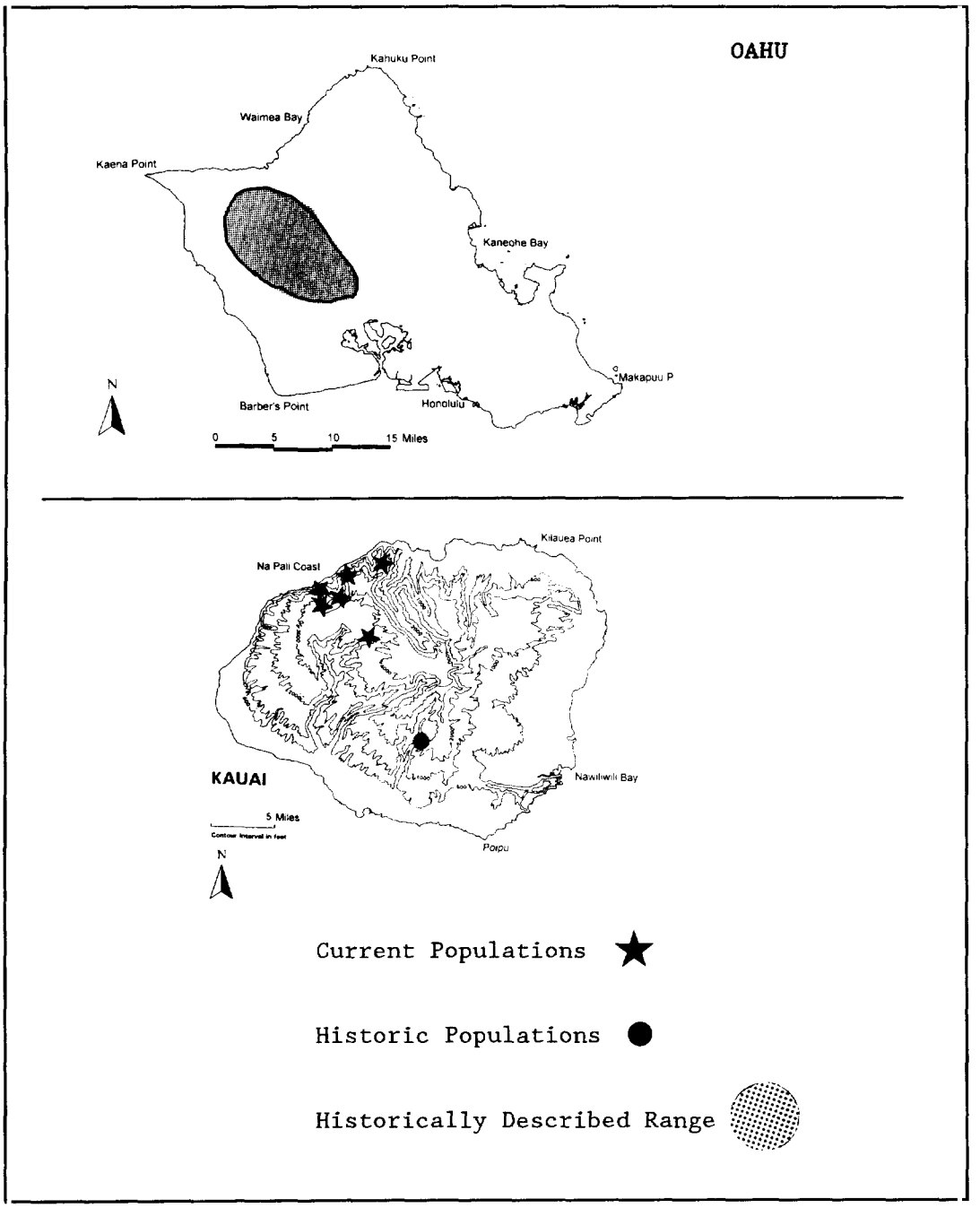
Current and Historic Range of *Lysimachia filifolia*



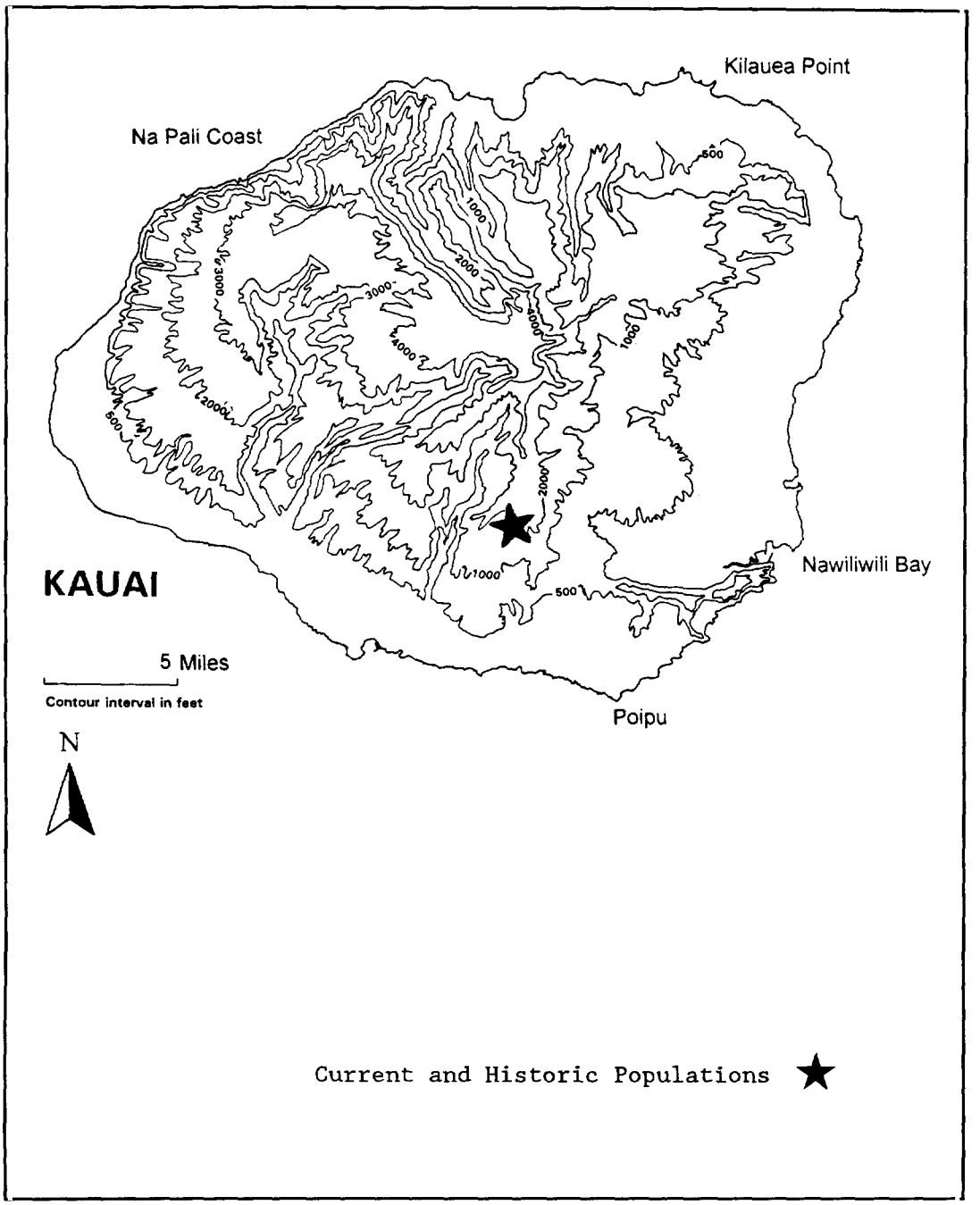
Current and Historic Range of *Melicope haupuensis*



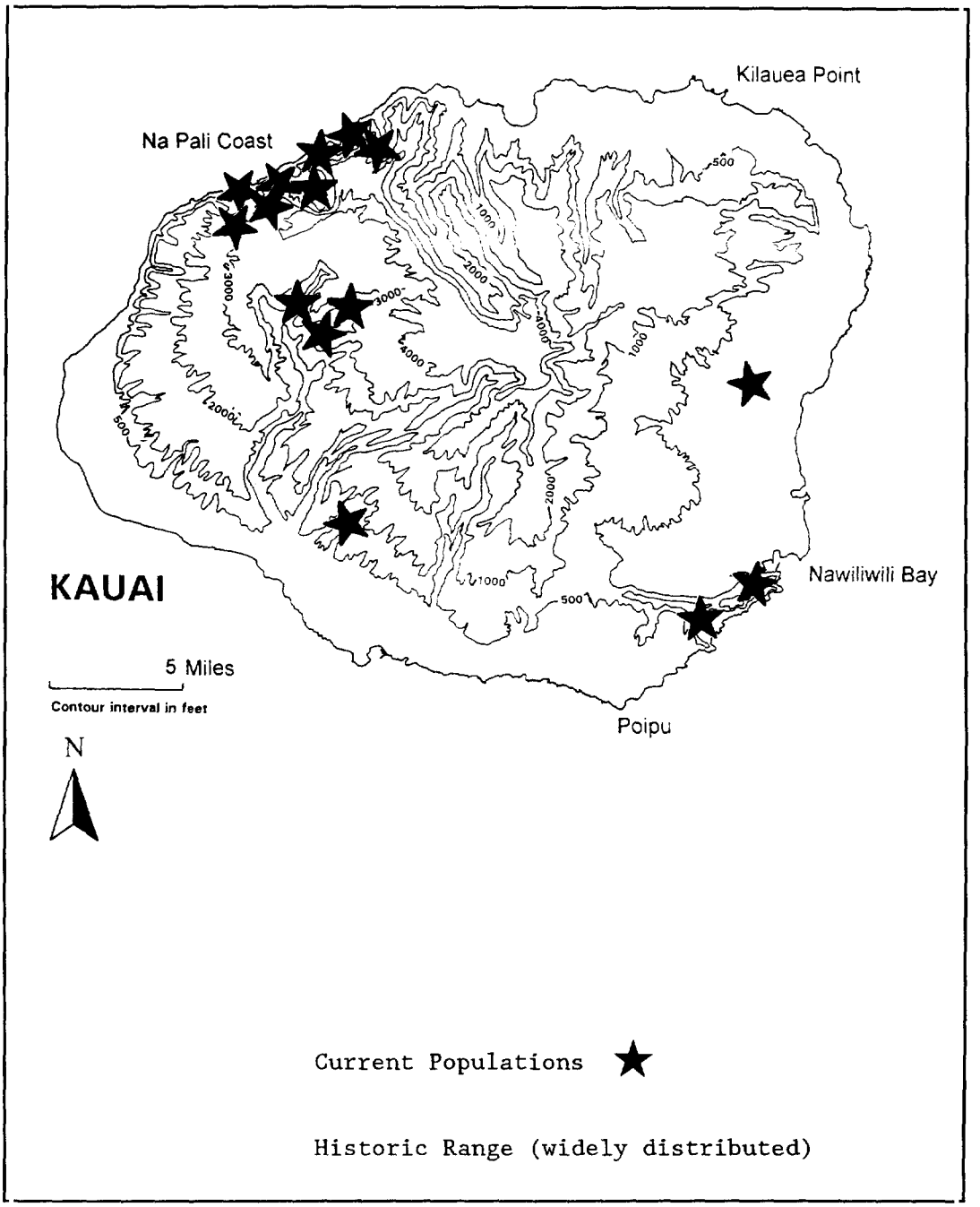
Current and Historic Range of *Melicope knudsenii*



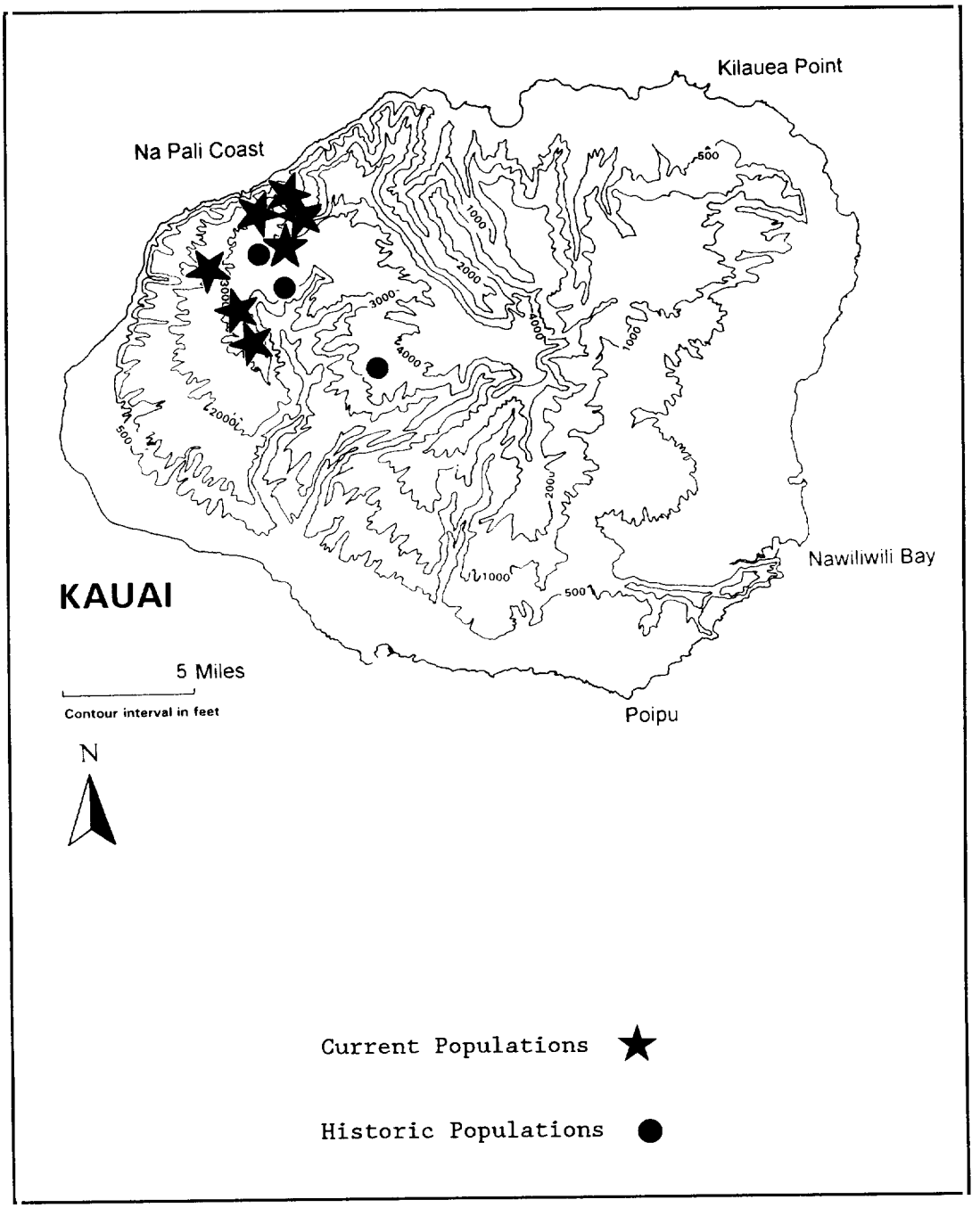
Current and Historic Range of *Melicope pallida*



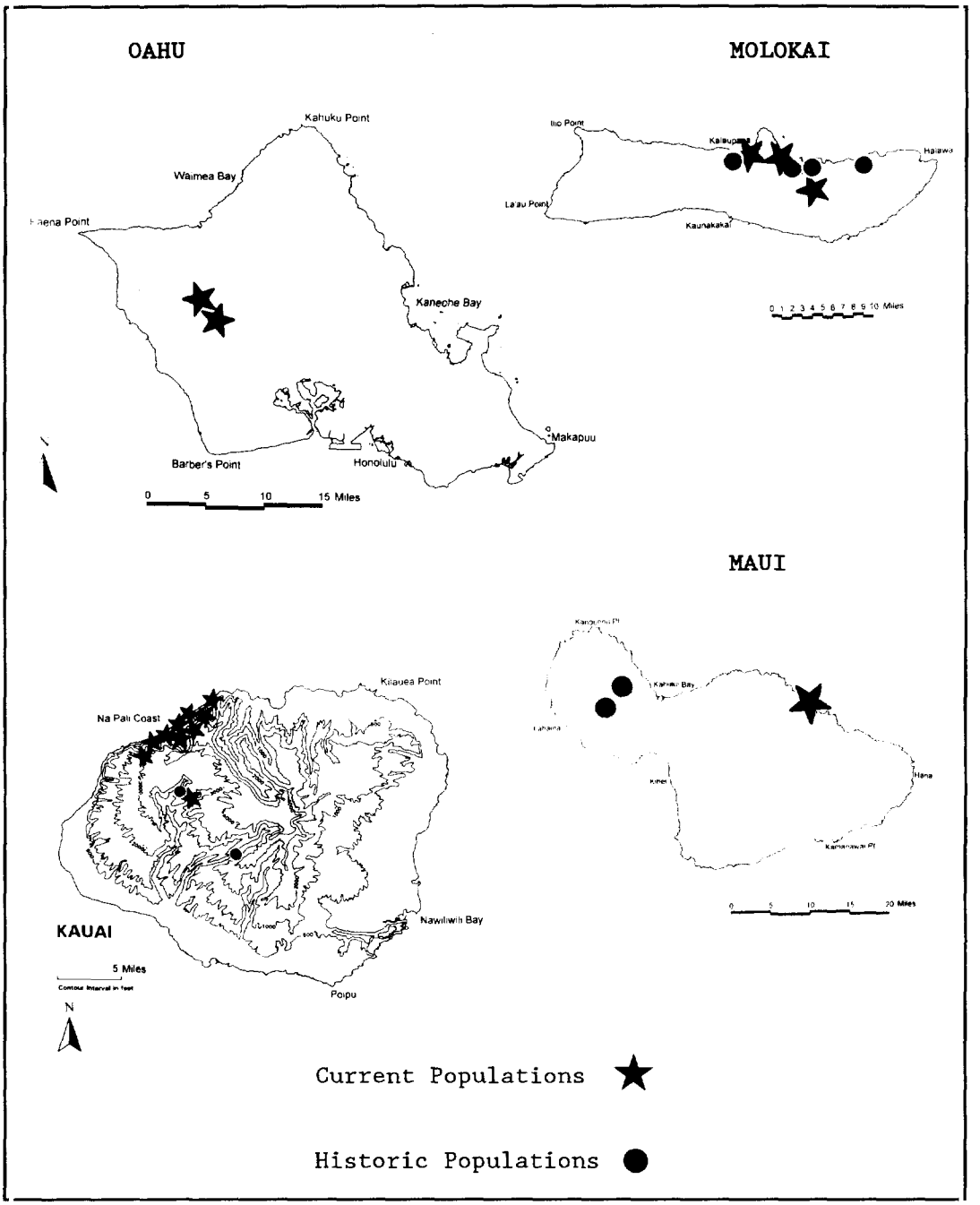
Current and Historic Range of *Melicope quadrangularis*



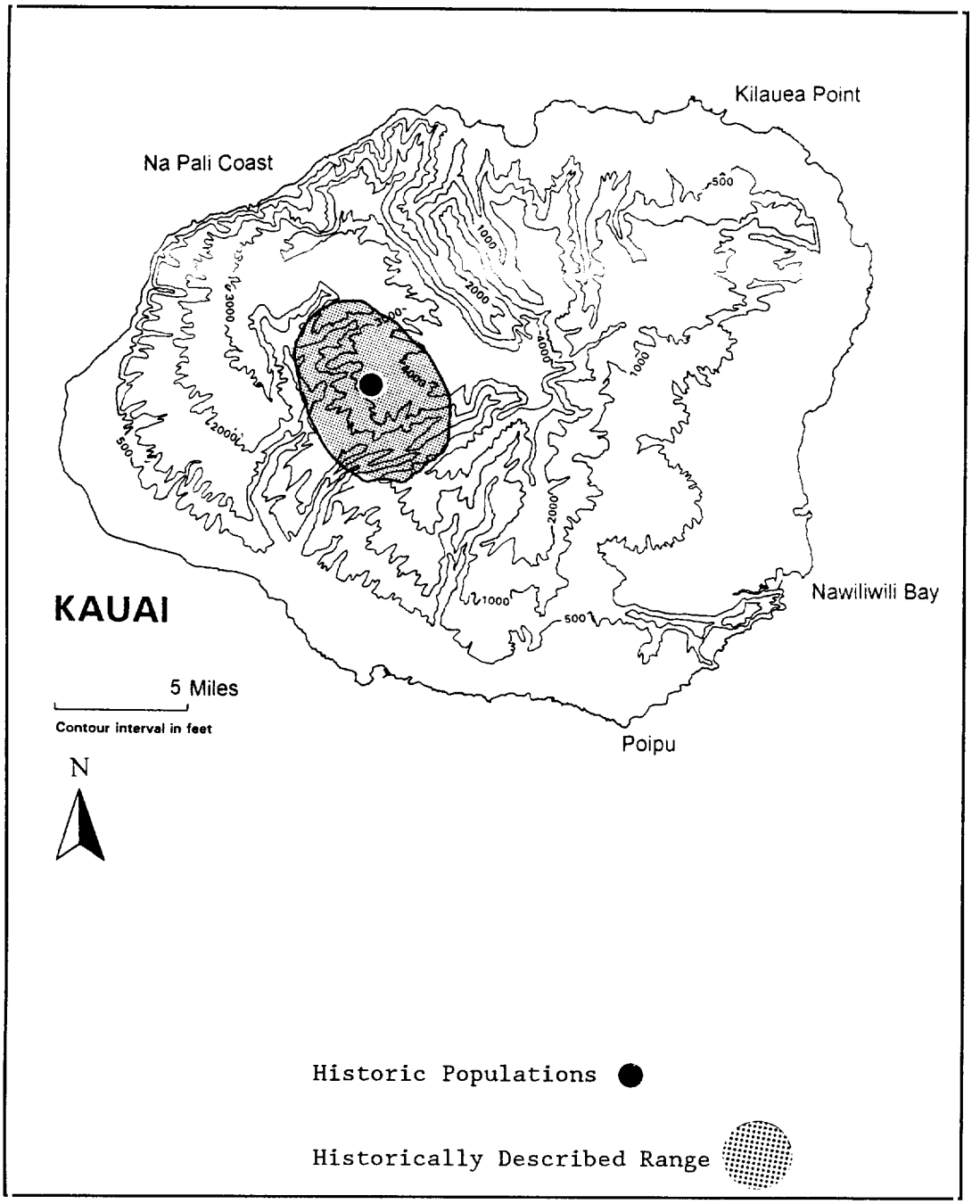
Current and Historic Range of *Munroidendron racemosum*



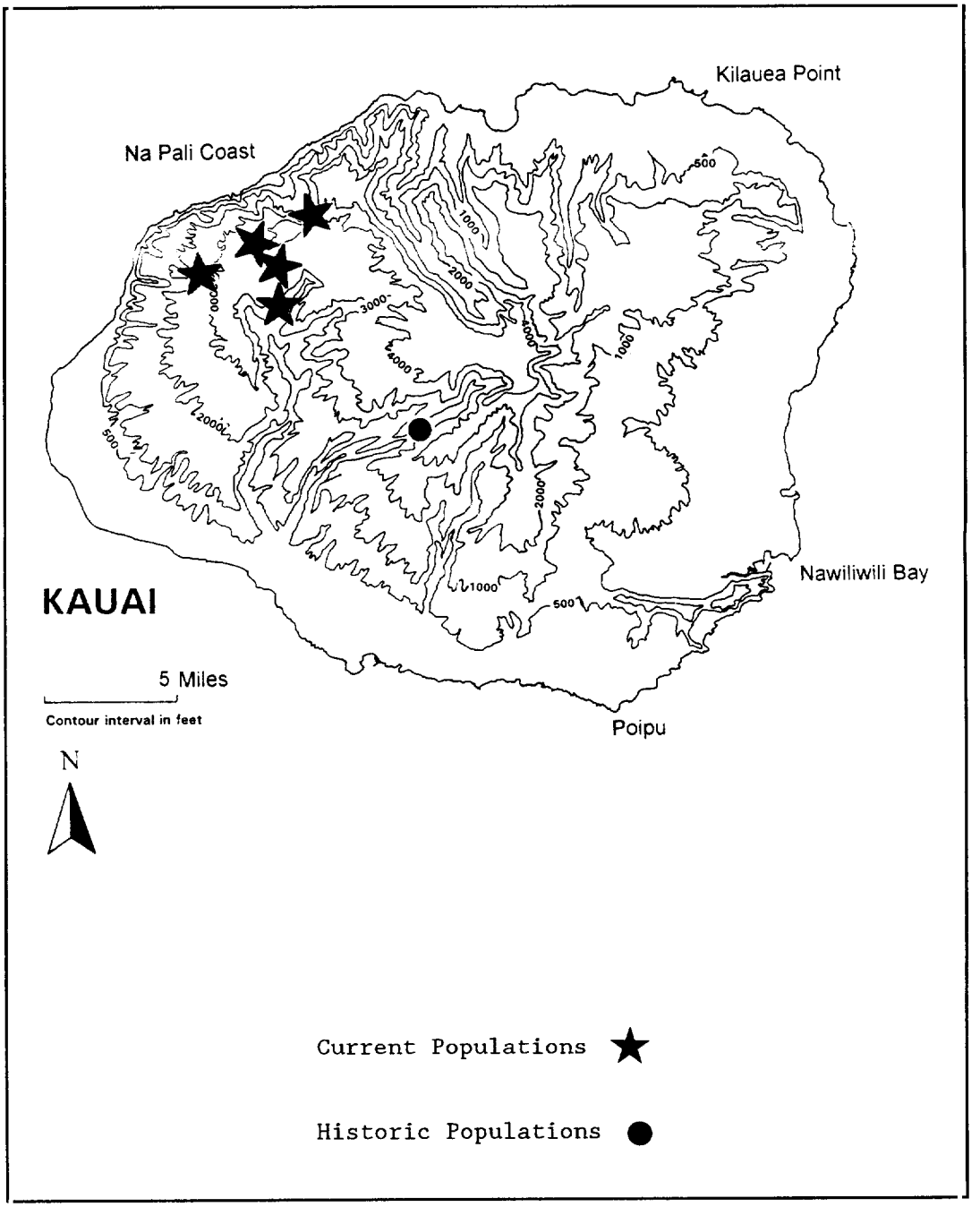
Current and Historic Range of *Nothocestrum peltatum*



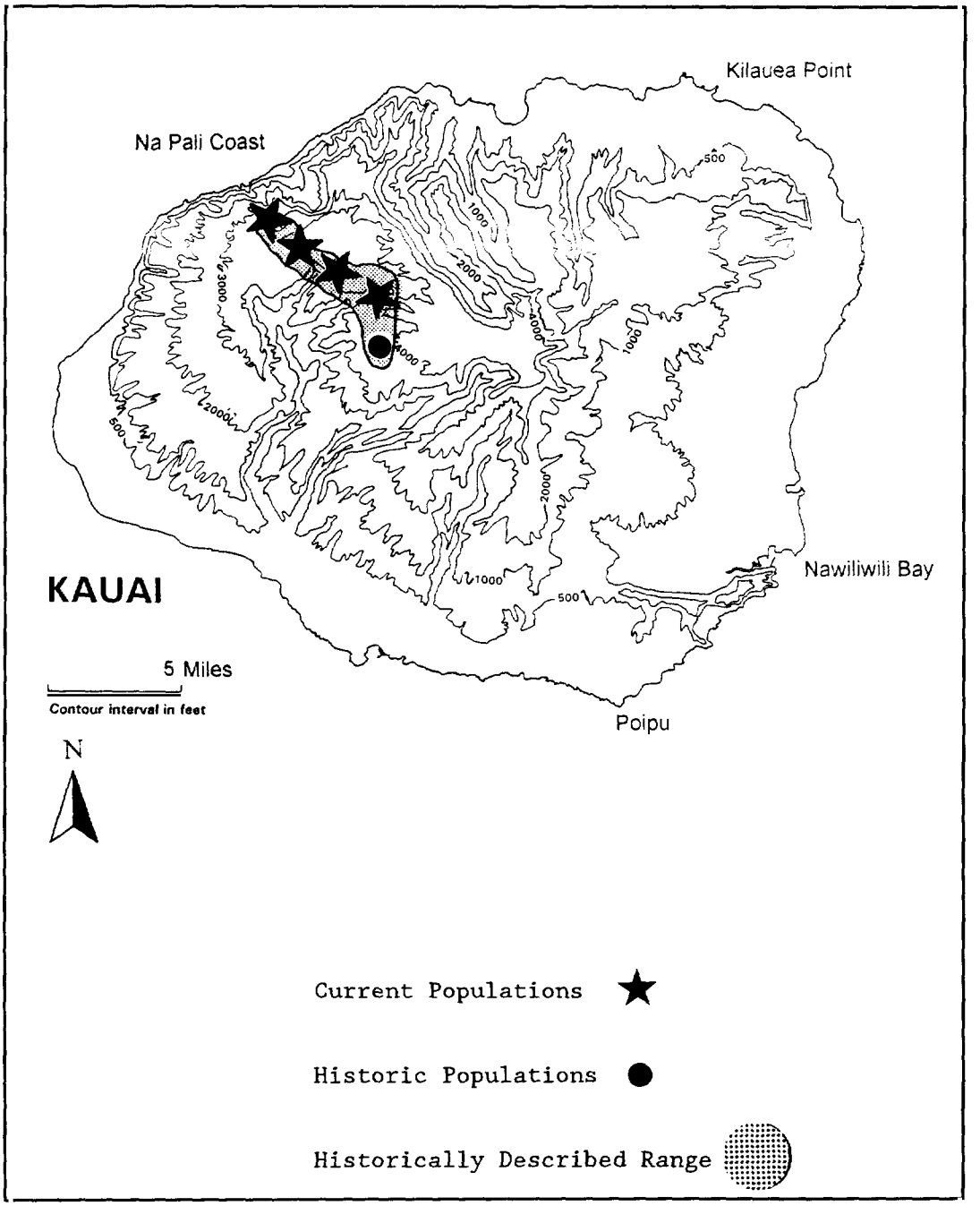
Current and Historic Range of *Peucedanum sandwicense*



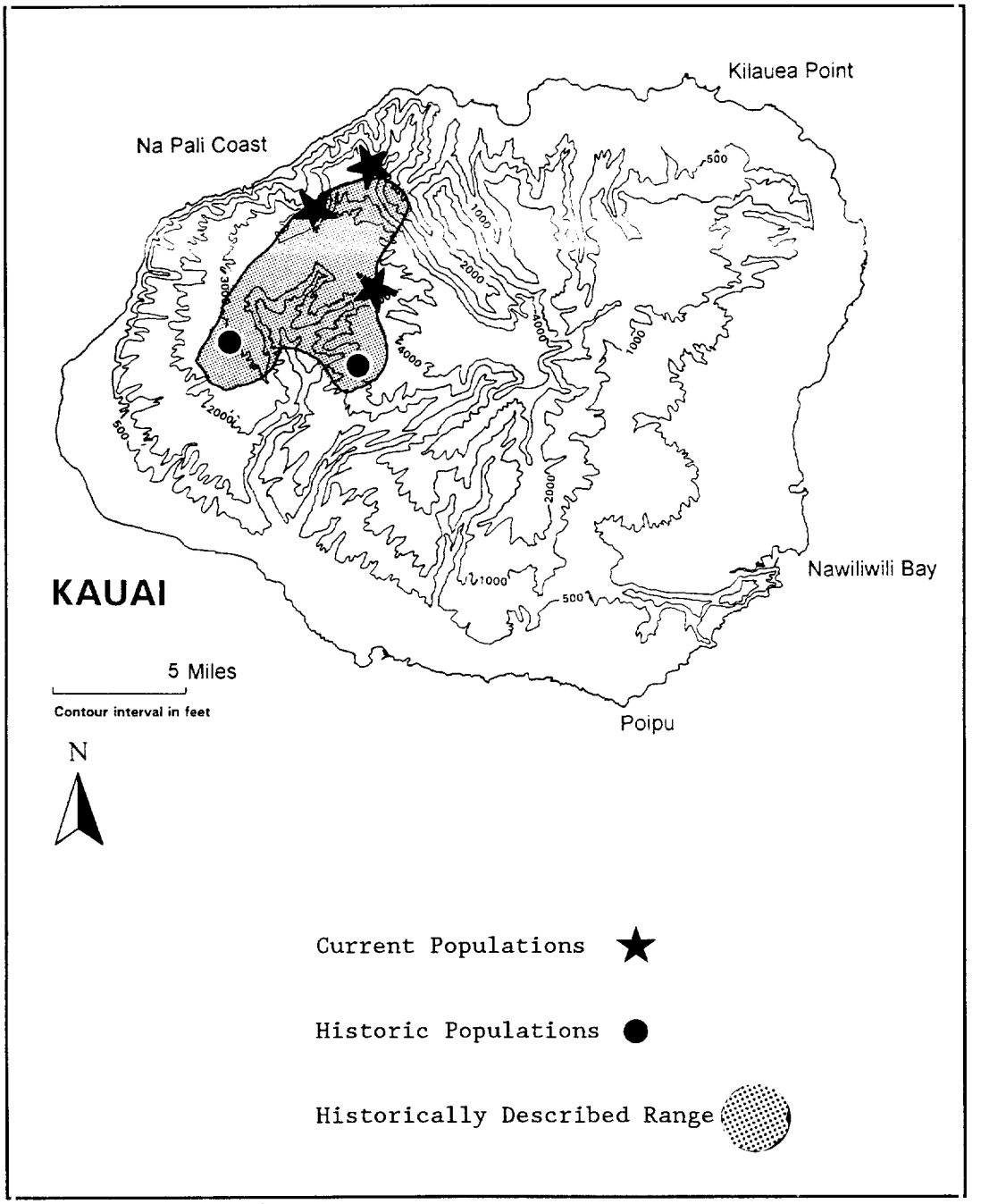
Current and Historic Range of *Phyllostegia waimeae*



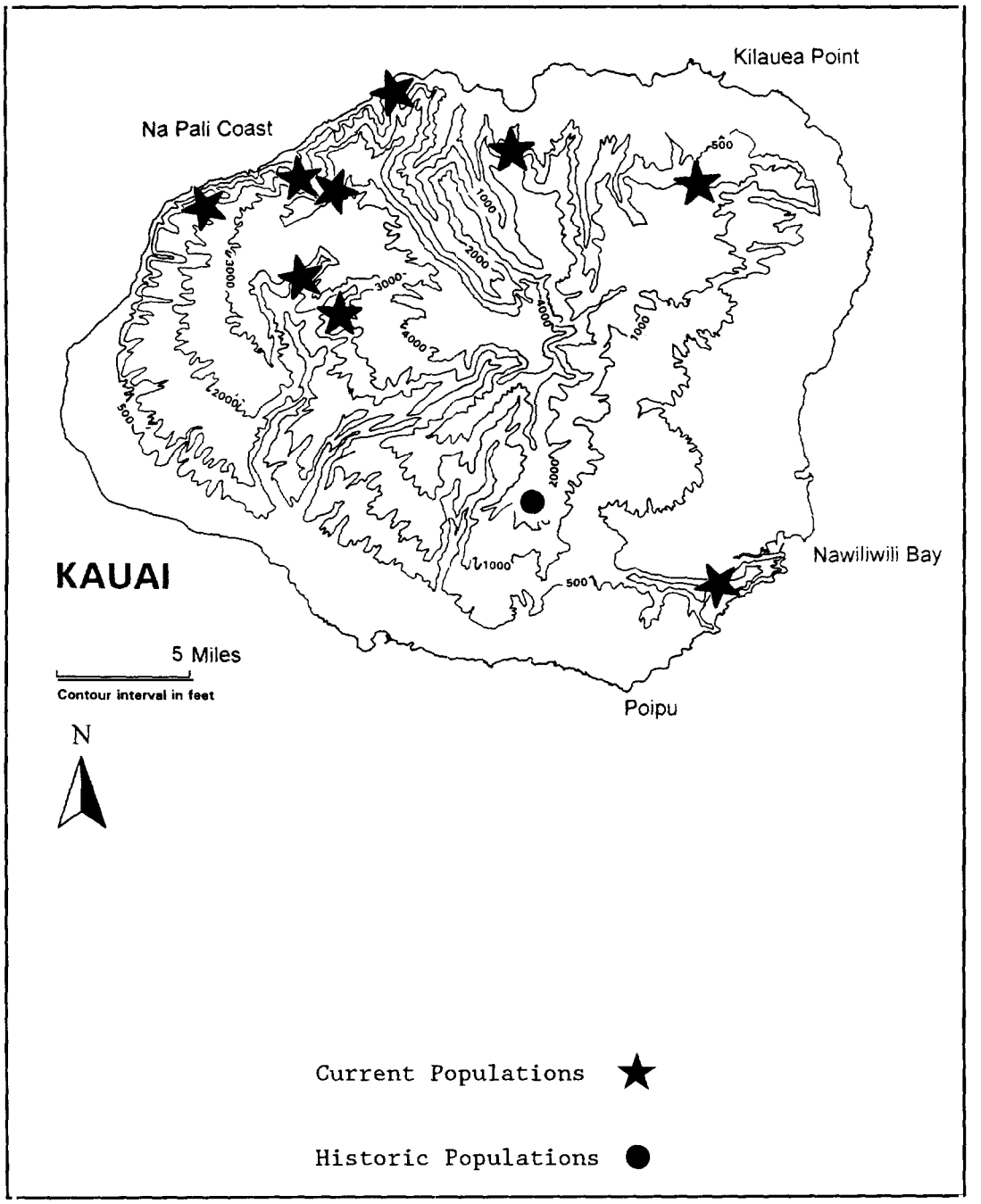
Current and Historic Range of *Poa mannii*



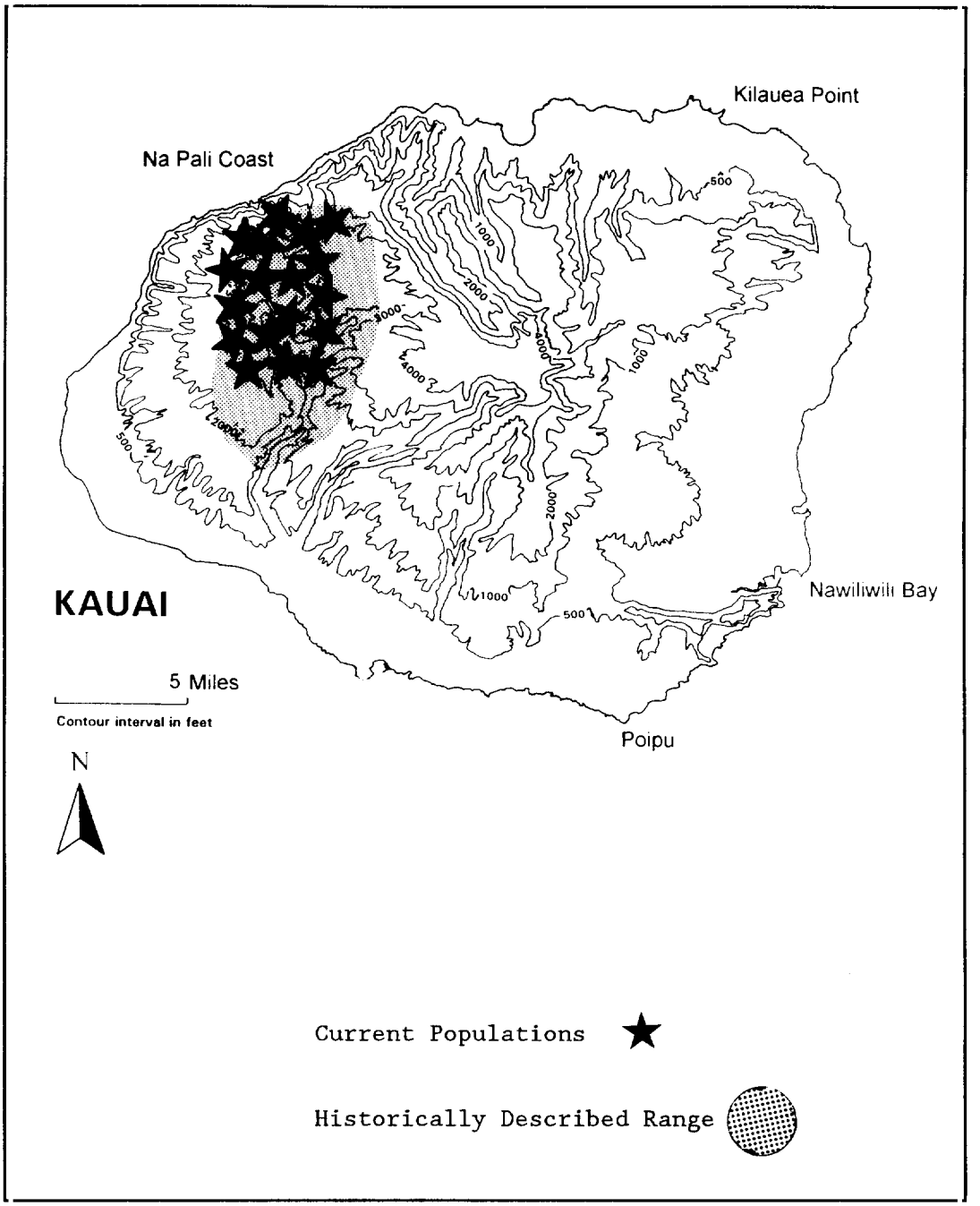
Current and Historic Range of *Poa sandvicensis*



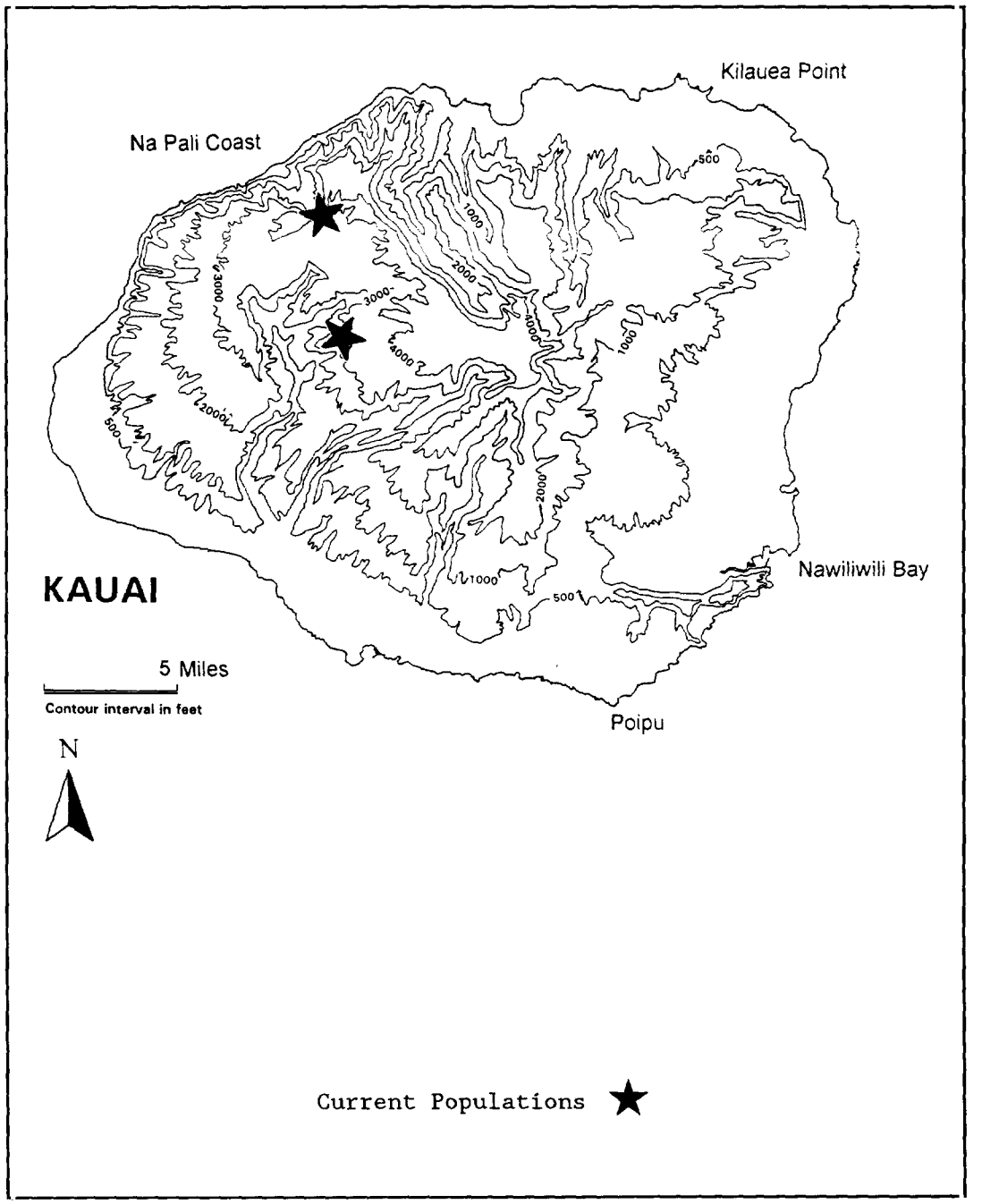
Current and Historic Range of *Poa siphonoglossa*



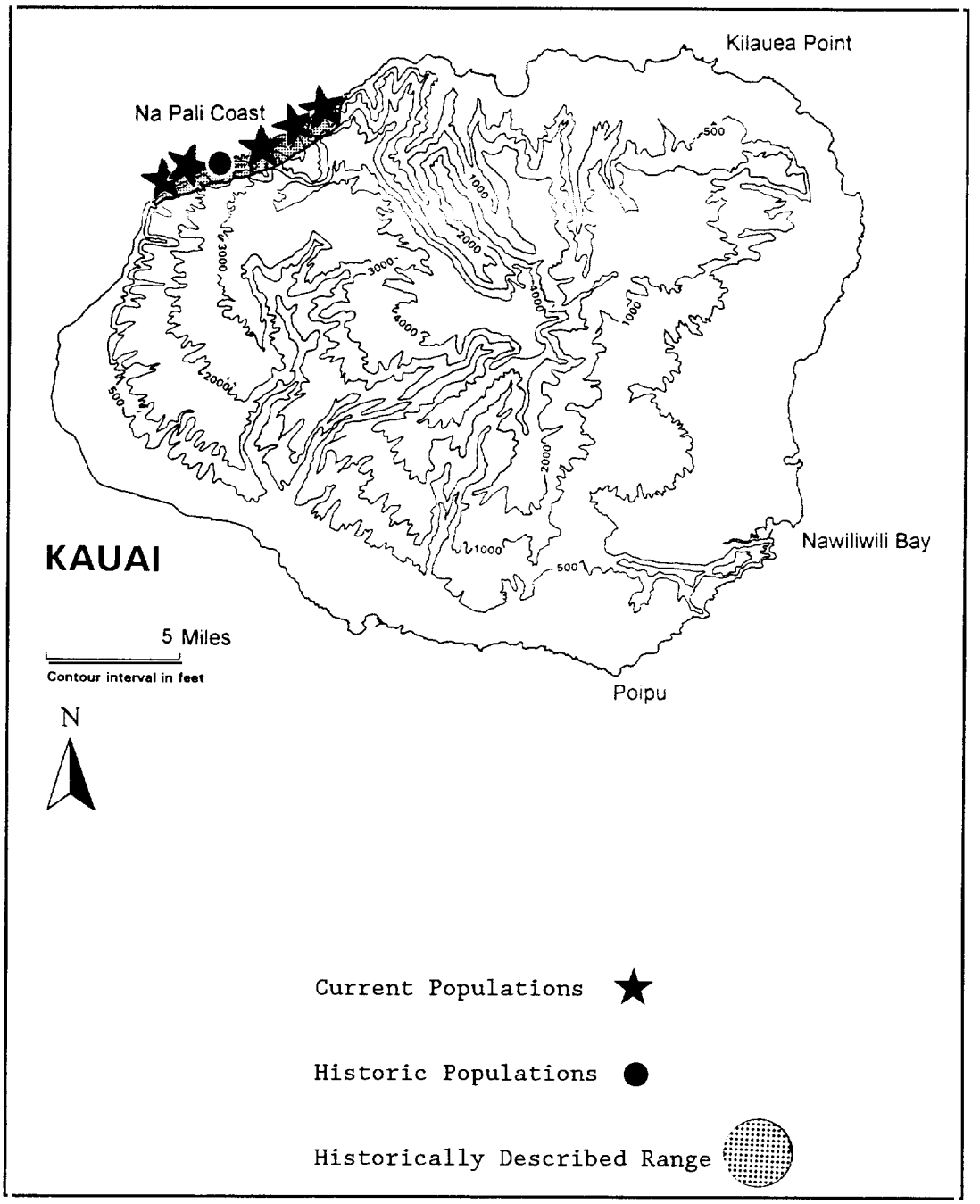
Current and Historic Range of *Pteralyxia kauaiensis*



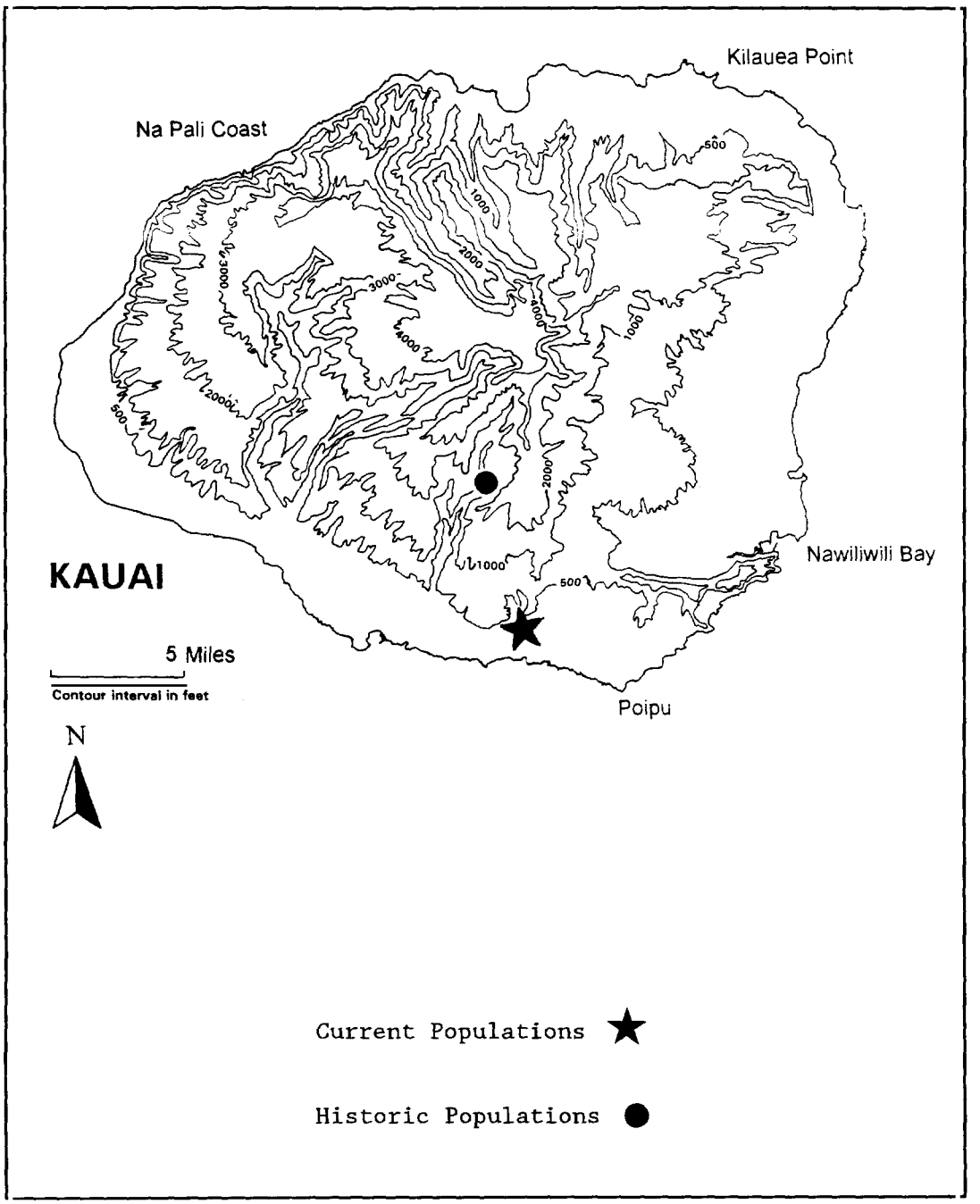
Current and Historic Range of *Remya kauaiensis*



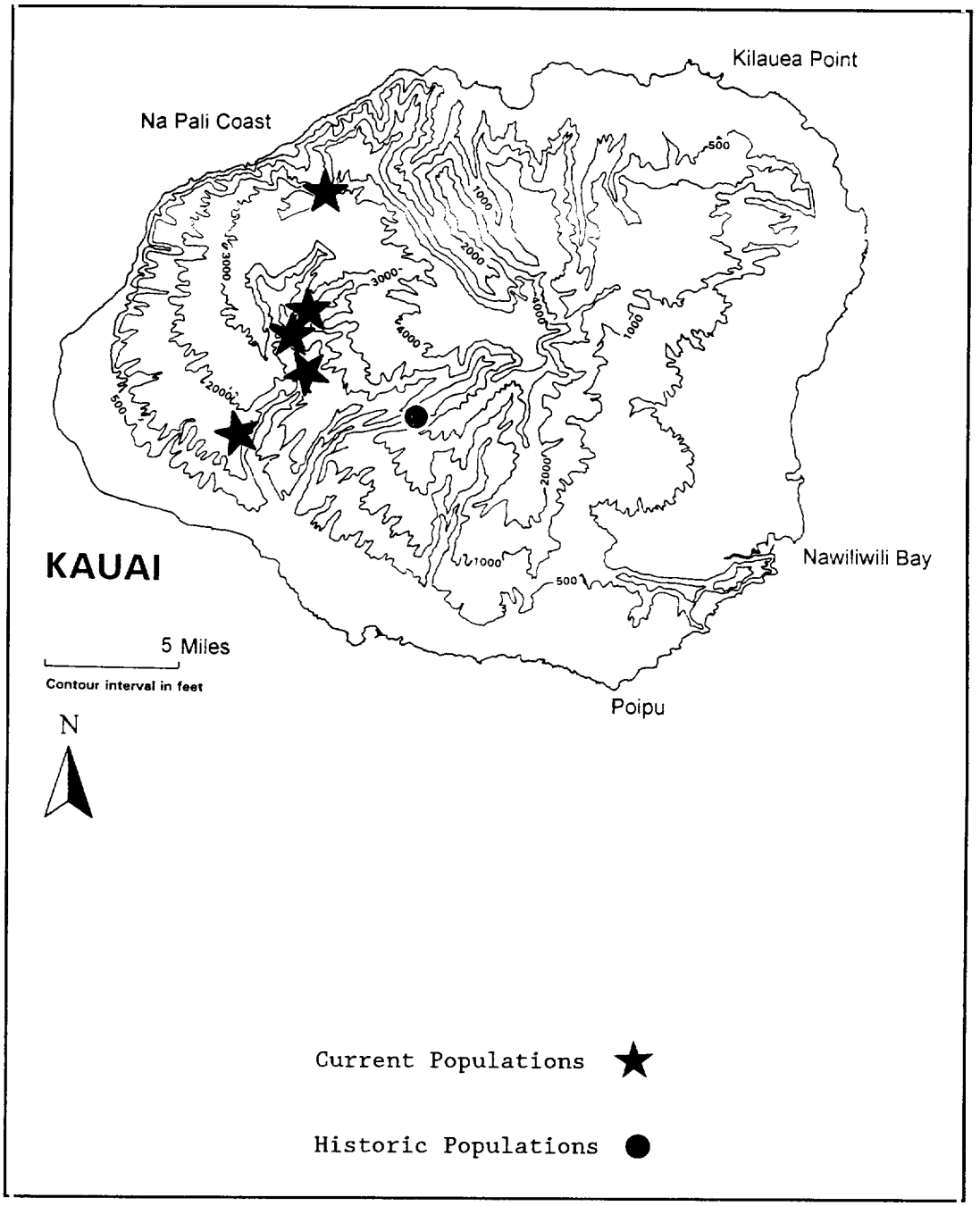
Current and Historic Range of *Remya montgomeryi*



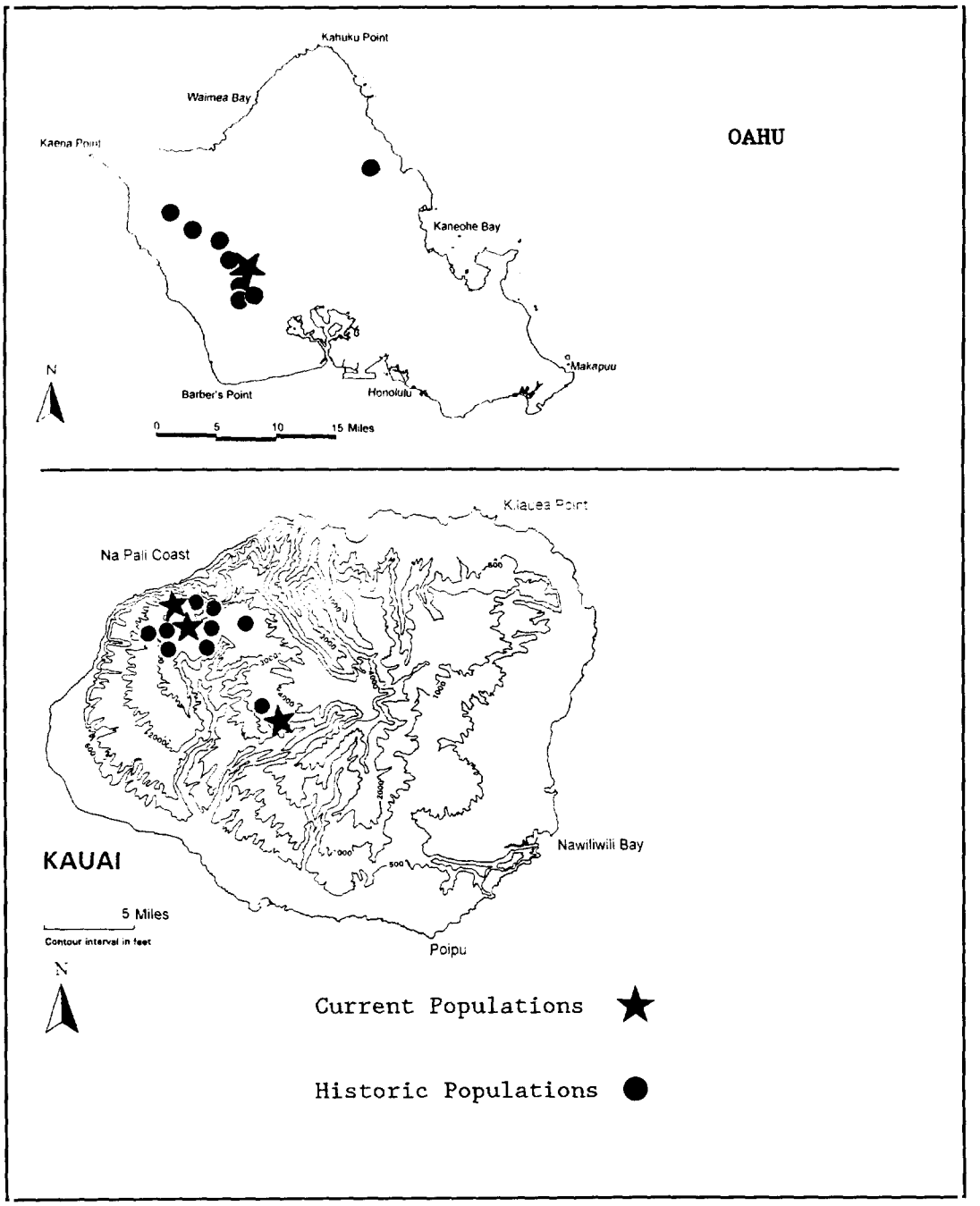
Current and Historic Range of *Schiedea apokremnos*



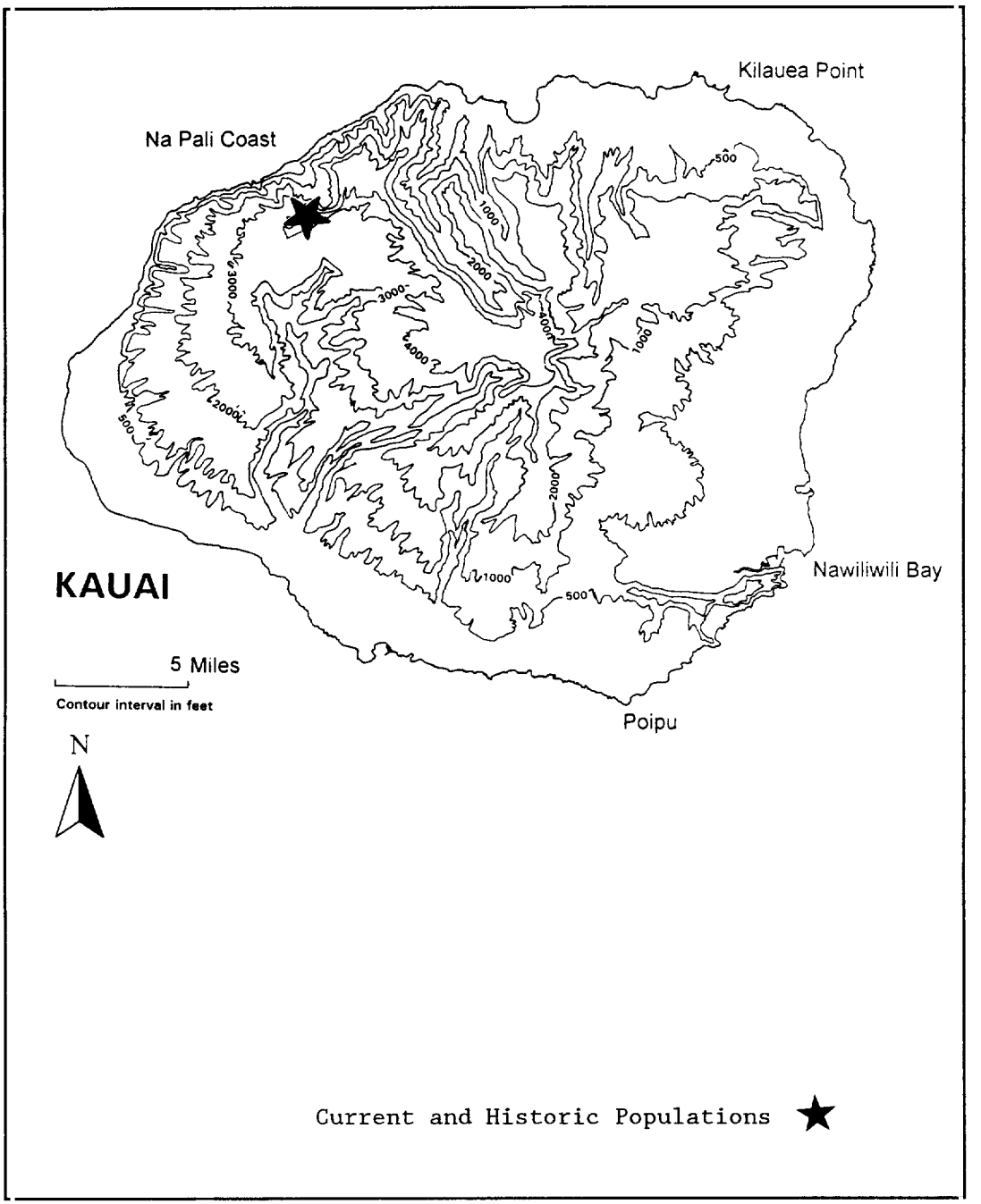
Current and Historic Range of *Schiedea spergulina* var. *leiopoda*



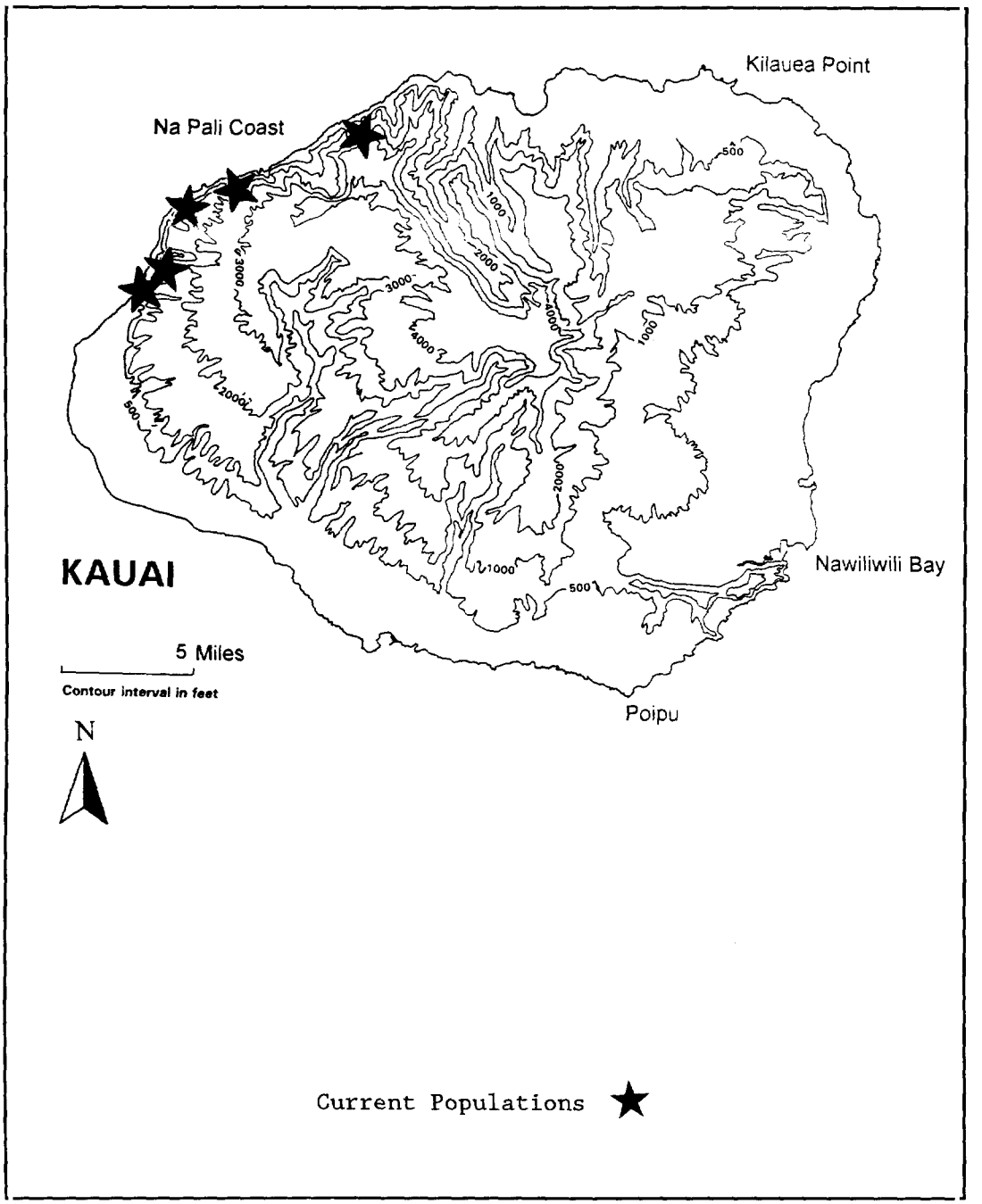
Current and Historic Range of *Schiedea spergulina* var. *spergulina*



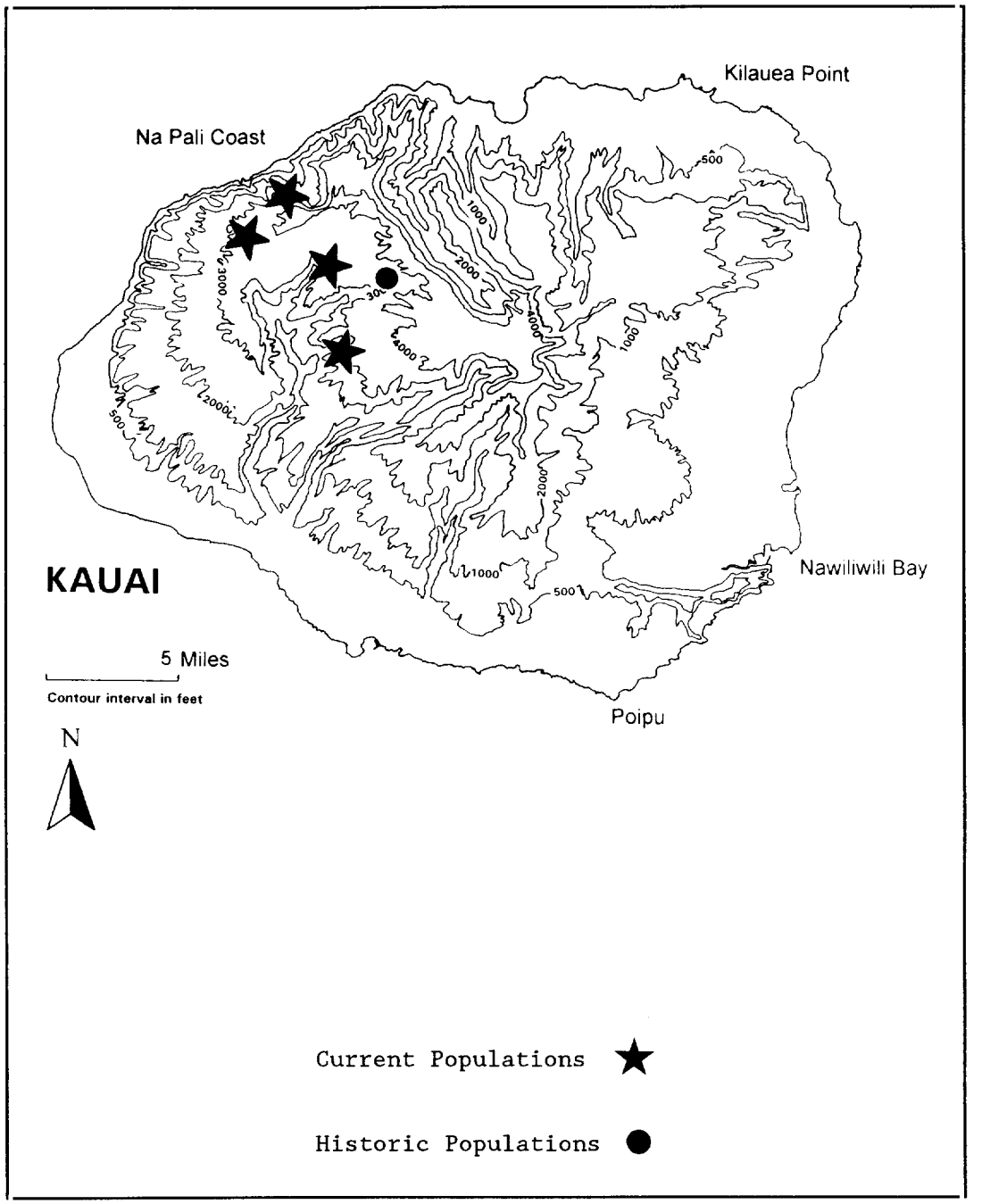
Current and Historic Range of *Solanum sandwicense*



Current and Historic Range of *Stenogyne campanulata*



Current and Historic Range of *Wilkesia hobdyi*



Current and Historic Range of *Xylosma crenatum*

APPENDIX D - SUMMARY OF ASSOCIATED SPECIES

COASTAL DRY SHRUBLANDS
Elevation: 0-300 meters (0-1,000 feet)
Rainfall: <1,200 millimeters (48 inches)/year

Kauai Cluster Taxa

Hedyotis st.-johnii
Munroidendron racemosum
Peucedanum sandwicense
Schiedea apokremnos
Wilkesia hobdyi

Associate Listed Species

Centaurium sebaeoides - E^3
Lobelia niihauensis - E^3
Mariscus pennatiformis ssp. *pennatiformis* - E^1
Sesbania tomentosa - E^1

Associated Candidates and Species of Concern

Capparis sandwichiana - SC
Hedyotis littoralis - SC
Panicum niihauense - C1

Associated Native Species

Artemisia australis, Canthium odoratum, Chamaesyce celestroides, Diospyros sandwicensis, Eragrostis variabilis, Lipochaeta connata, Metrosideros polymorpha, Scaevola, and *Sida fallax*

Associated Alien Species

Ageratina adenophora, Erigeron karvinskianus, Kalanchoe pinnata, Lantana camara, Leucaena leucocephala, Melinus minutiflora, Pluchea symphytifolia, Psidium guajava, Schinus terebinthifolius, Triumfetta semitriloba

LOWLAND DRY GRASSLAND
Elevation: 15-2,000 meters (50-6,500 feet)
Rainfall: <1,200 millimeters (48 inches)/year

Kauai Cluster Taxa

Brighamia insignis
Lipochaeta micrantha var. exigua
Lipochaeta micrantha var. *micrantha*

Associated Native Species

Canthium odoratum, *Chamaesyce celestroides*, *Chamaesyce celestroides* var. *hanapepensis*, *Diospyros sandwicensis*, *Eragrostis variabilis*, *Heteropogon contortus*, *Metrosideros polymorpha*, and *Neraudia kauaiensis*

Associated Alien Species

Ageratum conyzoides, *Erigeron karvinskianus*, *Kalanchoe pinnata*, *Lantana camara*, *Melinis multiflora*, *Pluchea symphytifolia*, *Psidium cattleianum*, *Psidium guajava*, *Setaria gracilis*, *Sporobolus africanus*, and *Stachytarpheta*

LOWLAND DRY FOREST
Elevation: 15-2,000 meters (50-6,500 feet)
Rainfall: <1,200 millimeters (48 inches)/year

Kauai Cluster Taxa

Delissea rhytidosperma
Hibiscus clayi
Melicope knudsenii
Wilkesia hobdyi

Associated Listed Species

Bonamia menziesii - E^1
Fluggea neowawraea - E^1
Silene lanceolata - E^7
Zanthoxylum hawaiiense - E^8

Associated Candidates and Species of Concern

Acacia koaie - SC
Canavalia pubescens - SC
Hibiscus kokio ssp. *kokio* - SC
Schiedea stellarioides - C1

Associated Native Species

Acacia koa, *Dianella sandwicensis*, *Diospyros sandwicensis*, *Dodonaea viscosa*, *Eragrostis variabilis*, *Myoporum sandwicense*, *Nestegis sandwicensis*, *Sida fallax*, *Styphelia tameiameiae*, and *Waltheria indica*

Associated Alien Species

Aleurites moluccana, *Araucaria columnaris*, *Cordyline fruticosa*, *Lantana camara*, *Leucaena leucocephala*, *Melinis multiflora*, *Paspalum conjugatum*, *Passiflora ligularis*,

Passiflora mollissima, *Pennisetum clandestinum*, *Pluchea symphytifolia*, *Psidium cattleianum*, *Schinus terebinthifolius*, and *Syzygium cumini*

LOWLAND AND MONTANE MESIC FOREST
Elevation: 15-2,700 meters (50-8,,800 feet)
Rainfall: 1,200-2,500 millimeters (48-100 inches)/year

Kauai Cluster Taxa

Chamaesyce halemanui
Delissea rhytidosperma
Diellia pallida
Dubautia latifolia
Lipochaeta faurei
Lipochaeta micrantha var. *exigua*
Lipochaeta micrantha var. *micrantha*
Lipochaeta waimeaensis
Melicope haupuensis
Melicope knudsenii
Melicope pallida
Melicope quadrangularis
Munroidendron racemosum
Nothocestrum peltatum
Peucedanum sandwicense
Phyllostegia waimeae
Poa mannii
Poa sandvicensis
Poa siphonoglossa
Pteralyxia kauaiensis
Remya kauaiensis
Remya montgomeryi
Schiedea spergulina var. *leiopoda*
Schiedea spergulina var. *spergulina*
Solanum sandwicense
Stenogyne campanulata
Xylosma crenatum

Associated Listed Species

Alectryon macrococcus var. *macrococcus* - E^2
Abutilon sandwicense - E^3
Bonamia menziesii - E^1
Ctenitis squamigera - E^6
Diellia erecta - E^1
Gouania meyenii - E^3
Hibiscadelphus distans - E^5
Lobelia niihauensis - E^3
Mariscus pennatiformis ssp. *pennatiformis* - E^1
Spermolepis hawaiiensis - E^1

Associated Candidates and Species of Concern

Acacia koaie - SC
Asplenium schizophyllum - SC
Bidens sandvicensis ssp. *confusa* - SC
Canavalia napaliensis - SC
Chamaesyce atrococca - SC
Charpentiera densiflora - SC
Cyanea leptostegia - SC
Cyanea recta - C1
Cyrtandra kealiae - SC
Cyrtandra pickeringii - SC
Delissea rivularis - C1
Dubautia microcephala - SC
Euphorbia haeleeleana - C1
Eurya sandwicensis - SC
Gardenia remyi - SC
Hibiscadelphus sp. nov. - C1
Hibiscus kokio ssp. *kokio* - SC
Hibiscus waimeae ssp. *saintjohnianus* - SC
Hibiscus waimeae ssp. *hannerae* - C1
Isodendrion laurifolium - C1
Isodendrion longifolium - C1
Kokia kauaiensis - C1
Labordia helleri - SC
Lepidium serra - SC
Lysimachia kalalauensis - SC
Lysimachia sp. nov. 1 - C1
Platanthera holochila - C1
Phyllostegia helleri - SC
Phyllostegia knudsenii - C1
Phyllostegia wawrana - C1
Pisonia wagneriana - SC
Pittosporum napaliense - SC
Platydesma rostrata - SC
Pritchardia napaliensis - C1
Psychotria hobdyi - SC
Ranunculus mauiensis - SC
Schiedea membranacea - C1
Schiedea nuttallii - C1
Tetraplasandra kavaiensis - SC

Associated Native Species

Acacia koa, Alphitonia ponderosa, Alyxia oliviformis, Antidesma platyphyllum, Artemisia australis, Athyrium sandwicensis, Bidens sandwicensis, Bobea brevipes, Broussaisia arguta, Canthium odoratum, Carex meyenii, Carex wahuensis, Chamaesyce celestroides var. *hanapepensis, Cheirodendron trigynum, Coprosma waimeae, Cyrtandra pickeringii, Dianella sandwicensis, Dicranopteris linearis, Diospyros sandwicensis, Dodonaea viscosa, Doryopteris, Dryopteris* sp., *Elaeocarpus*

bifidus, Eragrostis variabilis, Hedyotis terminalis, Hibiscus waimeae, Ilex anomala, Lepidium serra, Lipochaeta connata, Lysimachia glutinosa, Melicope anisata, Metrosideros polymorpha, Metrosideros waialeale, Myrsine lanaiensis, Neraudia kauaiensis, Nestegis sandwicensis, Nototrichium sandwicense, Pandanus tectorius, Peperomia leptostachya, Perottetia sandwicensis, Pipturus albidus, Pisonia, Plectranthus parviflorus, Poutaria sandwicensis, Pritchardia minor, Psychotria mariniana, Rauvolfia sandwicensis, Santalum freycinetianum, Sapindus oahuensis, Scaevola, Styphelia tameiameiae, Syzygium sandwicensis, Tetraplasandra sp., *Urera glabra, Vaccinium, Wilkesia gymnoxiphium*, and *Xylosma hawaiiense*

Associated Alien Species

Acacia mearnsii, Acacia melanoxylon, Aleurites moluccana, Cordyline fruticosa, Erigeron karvinskianus, Grevillea robusta, Hamakua pamakani, Hedychium gardnerianum, Kalanchoe pinnata, Lantana camara, Leucaena leucocephala, Lonicera japonica, Melia azedarach, Melinis muinutiflora, Myrica faya, Oplismenus hirtellus, Opuntis ficus-indica, Passiflora edulis, Passiflora ligularis, Passiflora mollissima, Pennisetum clandestinum, Pluchea symphytifolia, Psidium cattleianum, Psidium guajava, Rhynchelytrum repens, Rubus argutus, Schinus terebinthifolius, Setaria gracilis, Stachytarpheta, Stenotaphrum secundatum, Syzygium cumini, Toona ciliata, and *Triumfetta semitriloba*

WET FOREST
Elevation: 15-2,700 meters (50-8,800 feet)
Rainfall: >2,500 millimeters (100) inches)/year

Kauai Cluster Taxa

Cyanea asarifolia
Cyrtandra limahuliensis
Exocarpos luteolus
Hedyotis cookiana
Lysimachia filifolia
Melicope quadrangularis
Phyllostegia waimeae
Poa sandvicensis
Pteralyxia kauaiensis
Solanum sandwicense

Associated Listed Species

Adenophorus periens - E[1]
Cyanea undulata - E[4]
Diplazium molokaiense - E[6]

Dubautia pauciflorula - E^4
Hesperomannia lydgatei - E^4
Labordia lydgatei - E^4
Plantago princeps var. *anomala* - E^1
Plantago princeps var. *princeps* - E^1
Viola helenae - E^4

Associated Candidates and Species of Concern

Alsinidendron lychnoides - C1
Alsinidendron viscosum - C1
Chamaesyce remyi var *kauaiensis* - SC
Chamaesyce remyi var. *remyi* - SC
Chamaesyce sparsiflora - SC
Cyanea dolichopoda - C1
Cyanea kolekoleensis - C1
Cyanea linearifolia - SC
Cyanea sp. nov. - C1
Cyanea remyi - C1
Cyrtandra cyaneoides - C1
Cyrtandra oenobarba - SC
Dubautia imbricata ssp. *acronaea* - SC
Dubautia imbricata ssp. *imbricata* - SC
Dubautia knudsenii ssp. *filiformis* - C1
Gardenia remyi - SC
Geranium kauaiense - SC
Hedyotis tryblium - SC
Hibiscus kokio ssp. *kokio* - SC
Isodendrion longifolium - C1
Joinvillea ascendens ssp. *ascendens* - SC
Labordia pumila - SC
Labordia tinifolia var. *wahiawaensis* - C1
Lysimachia daphnoides - SC
Melicope macropus - SC
Melicope paniculata - SC
Melicope puberula - SC
Myrsine fosbergii - SC
Myrsine linearifolia - C1
Myrsine mezii - SC
Phyllostegia helleri - SC
Phyllostegia wawrana - C1
Phyllostegia wawrana - C1
Platanthera holochila - C1
Pritchardia hardyi - SC
Pritchardia viscosa - C1
Ranunculus mauiensis - SC
Schiedea helleri - C1
Tetraplasandra kavaiensis - SC
Viola kauaensis var. *wahiawaensis* - C1
Wikstroemia skottsbergiana - SC

Associated Native Species

Antidesma platyphyllum, Athyrium sandwicensis, Broussaisia arguta, Cheirodendron trigynum, Coprosma, Cyrtandra pickeringii, Dicranopteris linearis, Diospyros sandwicensis, Gunnera kauaiensis, Hedyotis elatior, Melicope, Metrosideros polymorpha, Metrosideros waialeale, Perottetia sandwicensis, Pilea peploides, Pouteria sandwicensis, Pritchardia minor, Psychotria sp., *Styphelia tameiameiae, Syzygium sandwicensis, Touchardia latifolia*, and *Urera glabra*

Associated Alien Species

Ageratina riparia, Aleurites moluccana, Clidemia hirta, Corynocarpus laevigatus, Cuphea carthenensis, Erechites valerianifolia, Erigeron karvinskianus, Hedychium gardnerianum, Hydrocotyle sibthorpioides, Lantana camara, Lonicera japonica, Melastoma candidum, Myrica faya, Passiflora mollissima, Paspalum conjugatum, Psidium cattleianum, Psidium guava, Rubus argutus, and *Schefflera actinophylla*

C1 = Candidate for immediate listing
SC = Species of concern that are not presently candidates
[1] = Recovery will be addressed in the Multi-Island Cluster Recovery Plan
[2] = Recovery is addressed in the Maui Cluster Recovery Plan
[3] = Recovery is addressed in the Waianae Cluster Recovery Plan
[4] = Recovery is addressed in the Wahiawa Cluster Recovery Plan
[5] = Recovery is addressed in the *Hibiscadelphus distans* Recovery Plan
[6] = Recovery will be addressed in the Ferns Recovery Plan
[7] = Recovery is addressed in the Molokai Cluster Recovery Plan
[8] = Recovery will be addressed in the Big Island Cluster Recovery Plan

APPENDIX E - SUMMARY OF LANDOWNERSHIP/MANAGEMENT

National Park Service

Peucedanum sandwicense

City and County of Honolulu

Peucedanum sandwicense

State of Hawaii

Department of Hawaiian Home Lands

Hibiscus clayi, Peucedanum sandwicense

Department of Land and Natural Resources

Division of Forestry and Wildlife

Brighamia insignis, Chamaesyce halemaui, Cyanea asarifolia, Cyrtandra limahuliensis, Delissea rhytidosperma, Diellia pallida, Dubautia latifolia, Exocarpos luteolus, Hedyotis cookiana, Hibiscus clayi, Lipochaeta fauriei, Lipochaeta micrantha var. *micrantha, Lipochaeta waimeaensis, Lysimachia filifolia, Melicope haupuensis, Melicope knudsenii, Melicope pallida, Munroidendron racemosum, Nothocestrum peltatum, Peucedanum sandwicense, Phyllostegia waimeae, Poa mannii, Poa sandvicensis, Poa siphonoglossa, Pteralyxia kauaiensis, Remya kauaiensis, Remya montgomeryi, Schiedea apokremnos, Schiedea spergulina* var. *spergulina, Solanum sandwicense, Wilkesia hobdyi, Xylosma crenatum*

NARS

Brighamia insignis, Chamaesyce halemanui, Delissea rhytidosperma, Diellia pallida, Dubautia latifolia, Hedyotis cookiana, Munroidendron sandwicense, Poa mannii, Pteralyxia kauaiensis, Remya kauaiensis, Wilkesia hobdyi, Xylosma crenatum

Division of State Parks

Brighamia insignis, Chamaesyce halemanui, Diellia pallida, Dubautia latifolia, Exocarpos luteolus, Hedyotis st.-johnii, Munroidendron racemosum, Nothocestrum peltatum, Peucedanum sandwicense, Poa mannii, Poa sanvicensis, Pteralyxia kauaiensis, Remya kauaiensis, Remya montgomeryi, Schiedea apokremnos, Solanum

sandwicense, Stenogyne campanulata, Wilkesia hobdyi, Xylosma crenatum

The Nature Conservancy of Hawaii

Peucedanum sandwicense, Solanum sandwicense

Private Landowners

Brighamia insignis, Cyrtandra limahuliensis, Hibiscus clayi, Lipochaeta micrantha var. *exigua, Schiedea spergulina* var. *leipoda, Melicope knudsenii, Melicope quadrangularis, Munroidendron racemosum, Peucedanum sandwicense, Pteralyyxia kauaiensis, Solanum sandwicense*

APPENDIX F - DETAILED DESCRIPTIONS OF ALIEN PLANTS AND INTRODUCED UNGULATES

Information in this appendix is taken directly from the listing package covering 24 of the Kauai cluster taxa (USFWS 1994a), although some portions have been slightly modified to include other taxa covered by this plan.

INTRODUCED UNGULATES

Goats (*Capra hircus*)

Goats were introduced to the main Hawaiian Islands in 1792. There are currently populations on all but one of the islands where the Kauai cluster taxa occur (Kauai, Oahu, Molokai, Maui, and Hawaii). All feral goats were removed from Niihau about 1910, but by that time they had already caused considerable damage to the dry and mesic forests there. On Kauai, feral goats have been present in drier, more rugged areas since the 1820s; they still occur in Waimea Canyon and along the Na Pali Coast, as well as in the drier perimeter of Alakai Swamp and even in its wetter areas during periods with low rainfall. Goats have been on Oahu since about 1820, and they currently occur in the northern Waianae Mountains. On Molokai, goats degrade dry forests at low elevations, and they are expanding their range. On Maui, goats have been widespread for 100 to 150 years and are common throughout the south slope of Haleakala (Medeiros et al. 1986). Goats are managed in Hawaii as a game animal and goat hunting is allowed year-round or during certain months, depending on the area. However, many herds populate inaccessible areas where hunting has little effect on their numbers (HHP 1990c). Feral goats eat native vegetation, trample roots and seedlings, cause erosion, and promote the invasion of alien plants. They are able to forage in extremely rugged terrain and have a high reproductive

capacity (Clarke and Cuddihy 1980, Cuddihy and Stone 1990, Culliney 1988, Scott et al. 1986, Tomich 1986, van Riper and van Riper 1982).

Many of the plants covered in this recovery plan survive only on steep cliffs inaccessible to goats. Their original ranges were probably much larger, and they are vulnerable to the long-term, indirect effects of goats, such as large-scale erosion (Corn et al. 1979).

Pigs (*Sus scrofa*)

European pigs, introduced to Hawaii by Captain James Cook in 1778, hybridized with domesticated polynesian pigs, became feral and invaded forested areas, especially wet and mesic forests and dry areas at high elevations. They are currently present on Kauai, Lanai, Oahu, Molokai, Maui, Niihau, and Hawaii, and inhabit rainforests and grasslands. While rooting in the ground in search of invertebrates and plant material, feral pigs disturb and destroy vegetative cover, trample plants and seedlings, and threaten forest regeneration by damaging seeds and seedlings. They disturb soil substrates and cause erosion, especially on slopes. Alien plant seeds are dispersed on their hooves and coats as well as through their digestive tracts, and the disturbed soil is fertilized by their feces, helping these plants to establish. Pigs are a major vector in the spread of banana poka (*Passiflora mollissima*), firetree (*Myrica faya*), and strawberry guava (*Psidium cattleianum*), and enhance populations of common guava (*Psidium guajava*), kahili ginger (*Hedychium gardnerianum*), Hamakua pamakani (*Argeratina riparia*), prickly Florida blackberry (*Rubus argutus*), sweet granadilla (*Passiflora ligularis*), and yellow ginger (*Hedychium flavescens*), all of which threaten one or more of the Kauai cluster taxa (Cuddihy and Stone 1990, Medeiros et al. 1986, Scott et al. 1986, Smith 1985, Stone 1985, Tomich 1986, Wagner et al. 1990).

Cattle (*Bos taurus*)

Cattle were introduced to the main Hawaiian Islands in 1793. Large feral herds developed as a result of restrictions on killing cattle decreed by King Kamehameha I. Feral cattle formerly occurred on Niihau, and, along with goats and sheep, caused much damage on the island (Stone 1985). On Kauai, parts of Kokee were leased for cattle grazing in the 1850s, and both sides of Waimea Canyon were supporting large cattle ranching operations by the 1870s (Joesting 1984, Ryan and Chang 1985). Cattle grazing began about 1920 in the Na Pali region. Cattle roamed lowland areas and eventually began invading wet forests from adjacent mesic areas. Around 1900, Augustus Knudsen, the district forester of Kauai and a rancher, realizing the amount of destruction being caused to the forests by cattle, initiated some fencing (Daehler 1973). Sugar company interests funded additional fencing as well as feral cattle removal to protect the forest from further degradation and safeguard water reserves for their crops (Wenkam 1969). On Kauai, feral cattle were still present in Kokee as late as 1960 and in the Puu Ka Pele area in the 1980s. Feral cattle are currently present in northwestern Oahu and on Hawaii. They no longer exist on Kauai, Maui, Niihau, Molokai or Lanai. Cattle eat native vegetation, trample roots and seedlings, cause erosion, create disturbed areas into which alien plants invade, and spread seeds of alien plants in their feces and on their bodies. The forest in areas grazed by cattle becomes degraded to grassland pasture, and plant cover is reduced for many years following removal of cattle from an area. In addition, several alien grasses and legumes purposely introduced for cattle forage have become noxious weeds (Cuddihy and Stone 1990, Scott et al. 1986, Tomich 1986).

Examples of plants whose habitats have been altered by feral and domestic cattle include *Hibiscus clayi* and *Munroidendron racemosum*. The Maui population of *Melicope knudsenii*, growing in an area currently used as a domestic cattle pasture, is directly

threatened by trampling (Degener and Degener 1959a, HHP 1994, Lamoureux 1982).

Mule Deer (*Odocoileus hemionus columbianus*)

Mule deer or black-tailed deer were brought to Kauai from Oregon in the 1960s to provide another animal for hunting, since the State had planned to reduce the number of goats on Kauai because they were so destructive to the landscape (Kramer 1971). There are about 400 mule deer in and near Waimea Canyon, with some invasion into Alakai Swamp in drier periods. Mule deer, legally hunted during only one month each year, trample native vegetation and cause erosion (Cuddihy and Stone 1990, Tomich 1986).

Axis Deer (*Axis axis*)

Axis deer were first introduced to the Hawaiian Islands in 1868 as a game animal on Molokai, later to Oahu and Lanai, and finally to East Maui in 1960. Hunting of axis deer is allowed only on Molokai and Lanai during two months of the year. Considerable damage has been done to the forests on Molokai and Lanai by this animal, especially through browsing of vegetation and compaction of the soil (Cuddihy and Stone 1990, Culliney 1988, Scott et al. 1986, Tomich 1986). With a population of about 100 animals on the lower southwest slope of Haleakala, the range of the axis deer is expanding on East Maui and constitutes a potential threat to *Melicope knudsenii* (Medeiros et al. 1986). On Molokai, axis deer are encroaching on Pelekunu Valley and are already present in Kalaupapa, thus posing a potential threat to populations of *Peucedanum sandwicense* in these areas (HHP 1994).

ALIEN PLANTS

A small tree, *Acacia confusa* (Formosa koa), was introduced to Hawaii for reforestation purposes and is naturalized in dry to

mesic, disturbed habitats on most of the Hawaiian Islands (Smith 1985, Wagner et al. 1990). *Acacia mearnsii* (black wattle) was introduced as a cultivated plant and has naturalized on five islands in pastures and dry to mesic forests (Wagner et al. 1990). It threatens *Exocarpos luteolus*. Two subshrubs in the genus *Ageratina* have naturalized in the Hawaiian Islands and are classified as noxious weeds by the State. *Ageratina adenophora* (Maui pamakani), naturalized in dry areas to wet forests on four islands and also classified as a noxious weed by the Federal government (7 CFR 360), threatens *Peucedanum sandwicense* (HHP 1994, Wagner et al. 1990). *Ageratina riparia* (Hamakua pamakani) is naturalized in disturbed, dry to mesic areas and wet forest on four islands and is a threat to *Lysimachia filifolia* as well as *Peucedanum sandwicense* (HHP 1994, National Tropical Botanical Garden (NTBG) 1994, Wagner et al. 1990). *Ageratum conyzoides* (maile hohono), an herb which is a common weed in many areas of the main Hawaiian Islands, threatens *Brighamia insignis* in some areas (HHP 1994, Wagner et al. 1990).

Although it is the official state tree of Hawaii, *Aleurites moluccana* (kukui) is not a native Hawaiian plant but was originally native to Malesia. It was brought to Hawaii by the Polynesian immigrants and is now a component of mesic valley ecosystems on all of the main islands except Kahoolawe (Wagner et al. 1990). One or more populations of *Diellia pallida, Hibiscus clayi*, *Lipochaeta fauriei*, *Munroidendron racemosum*, and *Pteralyxia kauaiensis* grow in areas with kukui, which may compete with these native species for space. *Hibiscus clayi* and *Lipochaeta fauriei* do not grow under a dense canopy, so kukui could prevent them from regenerating in an area. *Munroidendron racemosum* and *Pteralyxia kauaiensis*, overstory trees in native forests, are displaced when kukui dominates (HHP 1994, NTBG 1994, Lamoureux 1982). *Araucaria columnaris* (columnar araucaria), planted in Hawaii for reforestation and timber production and now found on all the main islands, threatens *Hibiscus clayi* (Little and Skolman 1989, Neal 1965). *Bidens pilosa* (Spanish needle), an annual herb naturalized

on all the main Hawaiian Islands, is a threat to *Peucedanum sandwicense* (Ganders and Nagata 1990, HHP 1994).

Classified as a noxious weed by the State of Hawaii, Koster's curse is an aggressive shrub found in mesic to wet forests on at least five islands in Hawaii (Almeda 1990). It is a threat to *Melicope pallida* and *Peucedanum sandwicense*. It is a potential threat to *Cyrtandra limahuliensis* (HHP 1990c). *Cordyline fruticosa* (ti) is a shrub which was brought to Hawaii by the Polynesian immigrants. Its original range is unknown, but in Hawaii it is now naturalized on all the main islands, except Kahoolawe, in hala forest and mesic valleys and forests, sometimes forming dense stands (Wagner et al. 1990). One or more populations of the following taxa compete for space with ti: *Diellia pallida*, *Delissea rhytidosperma*, *Hibiscus clayi*, *Lipochaeta micrantha* var. *exigua*, *Lysimachia filifolia*, *Munroidendron racemosum*, and *Pteralyxia kauaiensis* (HHP 1994, NTBG 1994). *Corynocarpus laevigatus* (karakanut), a tree introduced to Hawaii for reforestation, is now found on four islands and is a threat to *Exocarpos luteolus* (Wagner et al. 1990).

Brought to Hawaii as a cultivated herbaceous plant, *Erigeron karvinskianus* (daisy fleabane) is naturalized in wetter areas of four islands (Wagner et al. 1990). Invasion by daisy fleabane threatens *Exocarpos luteolus*, *Lipochaeta micrantha* var. *micrantha*, *Melicope pallida*, *Nothocestrum peltatum*, *Peucedanum sandwicense*, *Poa mannii* and *Pteralyxia kauaiensis* (HHP 1994, NTBG 1994). *Furcraea foetida* (Mauritius hemp), a large rosette plant naturalized on most islands in Hawaii on rocky ledges, slopes, and in pastures, threatens *Schiedea spergulina* var. *leiopoda* (Wagner et al. 1990).

Grevillea robusta (silk oak) was extensively planted in Hawaii for timber and is now naturalized on most of the main islands (Smith 1985, Wagner et al. 1990). Silk oak threatens *Lipochaeta waimeaensis* and *Peucedanum sandwicense* (NTBG 1994).

Three species of *Hedychium* (ginger), native to the Himalayas and surrounding areas, were brought to Hawaii as ornamentals and

are now naturalized in mesic or wet forests. Two of these species threaten one or more of the Kauai cluster taxa. Their rhizomes produce rapid, vegetative growth, forming dense ground cover that excludes other plants. The Wainiha population of *Cyrtandra limahuliensis* is threatened by yellow ginger. Kahili ginger produces red seeds which are distributed by alien fruit-eating birds; it threatens *Solanum sandwicense* (Cuddihy and Stone 1990, NTBG 1994, Nagata 1990, Smith 1985). *Kalanchoe pinnata* (air plant) is an herb which occurs on all the main islands except Niihau and Kahoolawe, especially in dry to mesic areas (Wagner et al. 1990). Populations of *Brighamia insignis* and *Peucedanum sandwicense* are threatened by competition with air plant (HHP 1994, Takeuchi 1982).

Lantana camara (lantana), brought to Hawaii as an ornamental plant, is an aggressive, thicket-forming shrub which can now be found on all of the main islands in mesic forests, dry shrublands, and other dry, disturbed habitats (Wagner et al. 1990). One or more populations of each of the following taxa are threatened by lantana: *Brighamia insignis*, *Delissea rhytidosperma*, *Diellia pallida*, *Hibiscus clayi*, *Lipochaeta fauriei*, both varieties of *Lipochaeta micrantha*, *Melicope haupuensis*, *Melicope knudsenii*, *Munroidendron racemosum*, *Nothocestrum peltatum*, *Peucedanum sandwicense*, *Poa mannii*, *Pteralyxia kauaiensis*, and both varieties of *Schiedea spergulina* (HHP 1994, NTBG 1994).

Leucaena leucocephala (koa haole), a shrub naturalized and sometimes the dominant species in low elevation, dry, disturbed areas on all of the main Hawaiian Islands, threatens the following plants: *Lipochaeta waimeaensis*, *Munroidendron racemosum*, *Schiedea apokremnos* and *Schiedea spergulina* var. *leiopoda* (Geesick et al. 1990, HHP 1994, Lamoureux 1982). *Lonicera japonica* (Japanese honeysuckle) is becoming naturalized in mesic to wet areas on Kauai and Hawaii and threatens *Solanum sandwicense* (Bruegmann 1990, NTBG 1994, Wagner et al. 1990). *Melastoma candidum*, a small cultivated shrub which is now naturalized in mesic to wet areas of Kauai, threatens some populations of *Cyrtandra limahuliensis*.

Melia azedarach (Chinaberry), a tree widely cultivated and naturalized on most of the main Hawaiian Islands, threatens *Diellia pallida*, *Munroidendron racemosum*, and *Schiedea spergulina* var. *spergulina* (HHP 1994, NTBG 1994, Wagner et al. 1990). The aggressive firetree has become a dominant plant in many mesic to wet forests on five Hawaiian Islands. Populations of *Exocarpos luteolus*, *Munroidendron racemosum*, and *Peucedanum sandwicense* are threatened by firetree (HHP 1994, HPCC 1994). *Opuntia ficus-indica* (prickly pear, panini) is a cactus found in dry, disturbed habitats on five islands which poses a threat to *Lipochaeta waimeaensis* (Solomon 1990).

Passiflora edulis (passion fruit) is a woody vine which occurs on five Hawaiian Islands in mesic forests and shrublands and threatens *Nothocestrum peltatum* (Escobar 1990, NTBG 1994). Sweet granadilla is a woody vine which now occurs in diverse mesic and wet forest on four islands and threatens *Delissea rhytidosperma* (Escobar 1990). Banana poka, another woody vine, poses a serious problem to mesic forests on Kauai and Hawaii by covering trees, reducing the amount of light which reaches trees as well as understory, and causing damage and death to trees by the weight of the vines. Animals, especially feral pigs, eat the fruit and distribute the seeds (Cuddihy and Stone 1990, Escobar 1990). Banana poka threatens *Delissea rhytidosperma*, *Dubautia latifolia*, *Nothocestrum peltatum*, *Peucedanum sandwicense*, *Pteralyxia kauaiensis*, and *Solanum sandwicense* (HHP 1994, NTBG 1994). *Pluchea carolinensis* (sourbush), a shrub naturalized in dry, coastal areas and mesic and wet forest on all of the main Hawaiian Islands, threatens *Hedyotis st.-johnii*, *Lysimachia filifolia* and *Peucedanum sandwicense* (NTBG 1994, Wagner et al. 1990).

Two shrubs or small trees, strawberry guava and common guava were brought to Hawaii and have become widely naturalized on all the main islands, forming dense stands in disturbed areas. Strawberry guava, found in mesic and wet forests, develops into stands in which few other plants grow, physically displacing natural vegetation and greatly affecting Hawaiian plants, many of

which are narrowly endemic taxa. Pigs eat strawberry guava and common guava fruit and disperse the seeds (Smith 1985, Wagner et al. 1990). Strawberry guava is considered to be the greatest weed problem in Hawaiian rain forests and is known to pose a threat to *Brighamia insignis*, *Chamaesyce halemanui*, *Cyrtandra limahuliensis*, *Hibiscus clayi*, *Lipochaeta fauriei*, *Lipochaeta micrantha* var. *exigua*, *Pteralyxia kauaiensis*, *Solanum sandwicense*, and *Xylosma crenatum*, and it is a potential threat to *Melicope quadrangularis* (HHP 1994, NTBG 1994, Smith 1985, Lorence and Flynn 1991). Common guava invades disturbed sites, forming dense thickets in dry as well as mesic and wet forests (Smith 1985, Wagner et al. 1990). Common guava threatens *Brighamia insignis*, *Cyrtandra limahuliensis*, *Hibiscus clayi*, *Lipochaeta fauriei*, *Melicope pallida*, *Munroidendron racemosum*, *Peucedanum sandwicense*, and *Pteralyxia kauaiensis* (Lamoureux 1982, HHP 1994, NTBG 1994).

Prickly Florida blackberry, an aggressive alien species in disturbed mesic to wet forests and subalpine grasslands on four islands, is considered a noxious weed by the State of Hawaii (Smith 1985, Wagner et al. 1990). Prickly Florida blackberry threatens *Exocarpos luteolus*, *Melicope pallida*, *Melicope quadrangularis*, *Nothocestrum peltatum*, *Poa mannii*, *P. sandvicenis*, *P. siphonglossa*, and *Solanum sandwicense* (HHP 1994, NTBG 1994). *Rubus rosifolius* (thimbleberry) is naturalized in disturbed mesic to wet forests (Wagner et al. 1990) and threatens *Cyrtandra limahuliensis* (USFWS 1994a). *Schefflera actinophylla* (octopus tree), brought to Hawaii as a cultivated tree, is shade tolerant and becomes established in undisturbed forests (Lowrey 1990, Smith 1985). It is now naturalized on at least four islands and is a threat to *Lysimachia filifolia* as well as a potential threat to *Peucedanum sandwicense* (HHP 1990c, NTBG 1994).

After escaping from cultivation, *Schinus terebinthifolius* (Christmas berry) became naturalized on most of the main Hawaiian Islands (Wagner et al. 1990). It threatens *Hibiscus clayi* and is a potential threat to *Peucedanum sandwicense* (HHP 1990c, NTBG 1994). Four species of the genus *Stachytarpheta* have naturalized

in the Hawaiian Islands, usually in disturbed areas (Wagner et al. 1990). These alien herbs or subshrubs threaten *Brighamia insignis* and *Peucedanum sandwicense* (HHP 1994, NTBG 1994). *Syzygium cumini* (Java plum), a tree naturalized in disturbed mesic forests on most of the main Hawaiian Islands, threatens *Hibiscus clayi* (HHP 1994; NTBG 1994; Wagner et al. 1990). *Triumfetta semitriloba* (Sacramento bur) is a subshrub now found on four Hawaiian Islands and considered to be a noxious weed by the State of Hawaii (Wagner et al. 1990). Populations of *Munroidendron racemosum* and *Schiedea spergulina* var. *spergulina* are threatened by Sacramento bur (HHP 1994, NTBG 1994). *Toona ciliata* (Australian red cedar), a tree now naturalized on four Hawaiian Islands, is quickly spreading in forests of the Waianae Mountains on Oahu and threatens *Melicope pallida* (Wagner et al. 1990).

Several hundred species of grasses have been introduced to the Hawaiian Islands, many for animal forage. Approximately 100 grass species have become naturalized. *Melinis minutiflora* (molasses grass), a perennial grass brought to Hawaii for cattle fodder, is now naturalized in dry to mesic, disturbed areas on most of the main Hawaiian Islands. The mats it forms smother out other plants and fuel more intense fires than would normally affect an area (Cuddihy and Stone 1990, O'Connor 1990, Smith 1985). Plants threatened by molasses grass are *Brighamia insignis*, *Lipochaeta fauriei*, *Peucedanum sandwicense* and *Wilkesia hobdyi*(HHP 1994, NTBG 1994). *Oplismenus hirtellus* (basketgrass) is a perennial grass which is naturalized in shaded mesic valleys and forests and sometimes in wet forests on most of the main Hawaiian Islands (O'Connor 1990). *Diellia pallida*, *Hibiscus clayi*, and *Lipochaeta fauriei* are threatened by basketgrass (HHP 1994, NTBG 1994). The perennial grass *Paspalum conjugatum* (Hilo grass), naturalized in moist to wet, disturbed areas on most Hawaiian Islands, produces a dense ground cover, even on poor soil, and threatens *Cyrtandra limahuliensis* and *Hibiscus clayi* (Cuddihy and Stone 1990, O'Connor 1990, Smith 1985).

Pennisetum clandestinum (Kikuyu grass) is an aggressive, perennial grass introduced to Hawaii as a pasture grass. It it can withstand trampling and grazing and grows in thick mats which choke out other plants and prevents seedlings from establishing. Kikuyu grass has naturalized on four Hawaiian Islands in dry to mesic forest and has been declared a noxious weed by the U.S. Department of Agriculture (7 CFR 360) (Medeiros et al. 1986, O'Connor 1990, Smith 1985). Kikuyu grass threatens *Melicope knudsenii*. *Rhynchelytrum repens* (Natal redtop) is an annual or perennial grass which is naturalized in disturbed, usually dry, areas on all the main Hawaiian Islands and threatens *Lipochaeta waimeaensis* (O'Connor 1990). *Setaria gracilis* (yellow foxtail), a perennial grass naturalized in wet to dry, disturbed habitat on most of the main Hawaiian Islands, threatens *Brighamia insignis*, *Melicope haupuensis*, and *Peucedanum sandwicense* (HHP 1994, O'Connor 1990). A perennial grass naturalized in disturbed areas on most of the main Hawaiian Islands, *Sporobolus africanus* (smutgrass) threatens *Brighamia insignis* and *Peucedanum sandwicense* (HHP 1994, O'Connor 1990). *Stenotaphrum secundatum* (St. Augustine grass) threatens *Chamaesyce halemanui* and *Diellia pallida* (USFWS 1992a).

APPENDIX G - RECOVERY PRIORITY SYSTEM

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

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

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

APPENDIX H - SUMMARY OF COMMENTS

USFWS received comments on the Draft Recovery Plan for the Kauai Plant Cluster from DOFAW and NTBG. Most of these comments were minor and consisted of additional information on numbers of populations/individuals, distribution of certain taxa, cost estimates for tasks in the Implementation Schedule, and editorial changes. Most of these comments have been incorporated into the final plan. Additional comments are addressed specifically below:

Comment 1: The ecosystem approach for recovery plans is good, but the Kauai Recovery Plan lacks specifics, especially on allocation of funding and manpower where taxa cross jurisdictional boundaries.

Service Response: The Service agrees that the draft plan is very general. Recovery plans are not meant to be a step-by-step guide on how a manager should spend his/her money. They are guides containing recommendations for recovery with prioritized tasks. Based on comments received on the draft and recommendations from the Hawaii and Pacific Plant Recovery Coordinating Committee (HPPRCC), we have rewritten the Kauai Plan in a manner that makes it more specific and understandable to the manager.

Comment 2: The intent of the plan is good, but how will the targeted species of the ecosystem get priority? Will there be a recovery team assigned to do this?

Service Response: Responsible agencies are identified in the Implementation Schedule. We presume that these agencies will work together to implement agreed-upon recommendations. In addition, the Service is planning on establishing plant recovery teams to assist in the coordination and implementation of plant recovery efforts.

Comment 3: How will the priorities be assigned for taxa that occur on land managed by different state agencies?

Service Response: For the most part, recovery plans identify what needs to be done to recover species. Exactly how each task will be implemented may need to be worked out on a case-by-case basis, particularly when dealing with numerous landowners.

Comment 4: Recovery priority rankings do not always reflect the intensity and number of threats affecting the species or the number of plants left in the wild.

Service Response: Recovery priority number rankings take the potential for recovery into account, as well as the intensity and

number of threats affecting the taxon or the number of plants left in the wild.

Comment 5: What is the responsibility of the Division of State Parks in implementing tasks in the plan? Was State Parks consulted during the plan development?

Service Response: The Division of State Parks was sent the draft recovery plan during the public comment period. The Implementation Schedule has been changed to show that DLNR is responsible for implementing certain tasks. Both Divisions of DLNR (DOFAW and the Division of State Parks) should work together to coordinate the implementation of recovery tasks.