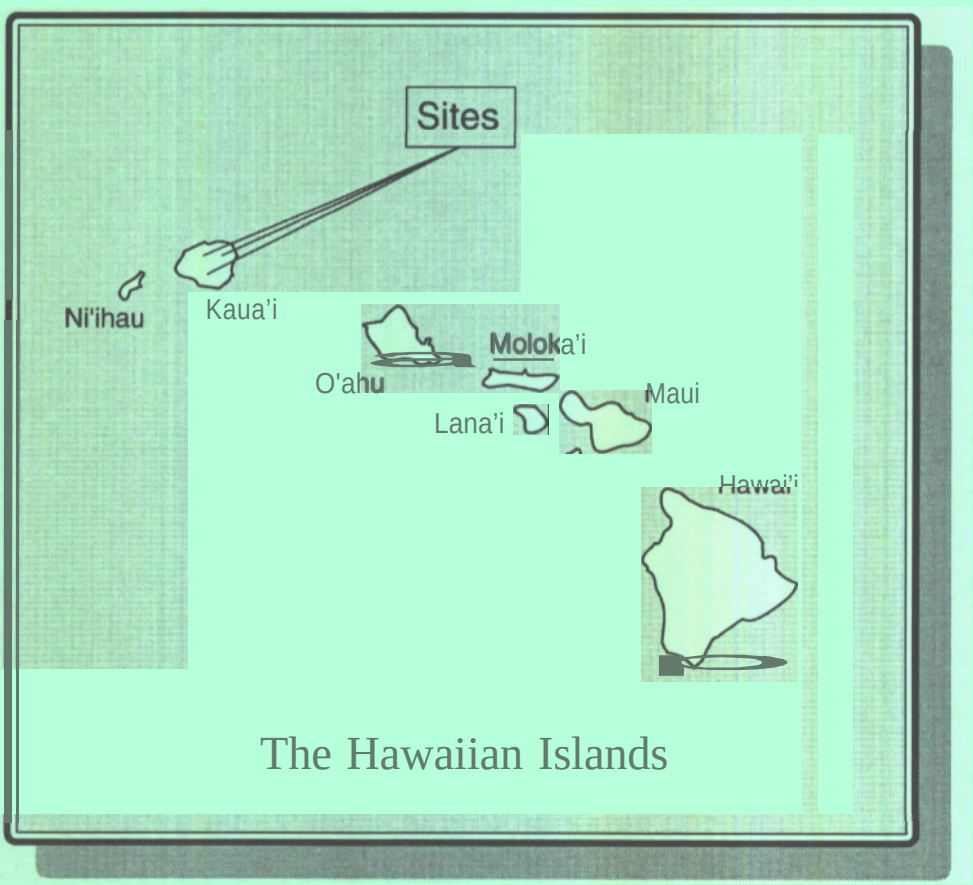
RECOVERY PLAN FOR THE WAHIAWA PLANT CLUSTER

CYANEA, UNDULATA, DUBAUTIA, PAUCIFLORULA, HESPEROMANNIA, LYDGATEI, LABORDIA LYDGATEI, AND VIOLA HELENAE

MAY 1994



U.S. Fish and Wildlife Service, Pacific Region

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RECOVERY PLAN FOR THE WAHIAWA PLANT CLUSTER: *CYANEA UNDULATA*, *DUBAUTIA PAUCIFLORULA*, *HESPEROMANNIA LYDGATEI*, *LABORDIA LYDGATEI*, AND *VIOLA HELENAE*

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

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ACKNOWLEDGEMENTS

The Recovery Plan for the Wahiawa Plant Cluster was prepared by Dr. David H. Lorence, Systematic Botanist, National Tropical Botanical Garden, Lawai, Kauai, Hawaii. Modifications have been made by the U.S. Fish & Wildlife Service.

EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR THE WAHIAWA PLANT CLUSTER

Current Species Status: All five species are federally listed as endangered with numbers of known remaining individuals as follows: Cyanea undulata, 28; Dubautia pauciflorula, 47; Hesperomannia lydgatei, 279; Labordia lydgatei, 23; and Viola helenae, 137. All but H. lydgatei and L. lydgatei are known only from the Wahiawa Drainage Area on the island of Kaua'i, Hawai'i. One H. lydgatei and two L. lydgatei individuals are known from the Waioli Stream Valley, and one L. lydgatei individual is known from the Makaleha Mountains, also on Kaua'i. Some reproduction is occurring in all of these species except L. lydgatei.

Habitat Requirements and Limiting Factors: The major habitat of all five species is the native wet Metrosideros forest surrounding the Wahiawa Bog in the Koloa district on the island of Kaua'i. They occur on gravelly and silty clay soils between 620 and 640 meters (2,033 to 2100 feet) elevation. L. lydgatei and/or H. lydgatei also occur in similar forest in the Waioli Stream Valley and Makaleha Mountains, Kaua'i. Invasion by alien plants is the greatest threat to all five species. Other threats include predation on seeds by insects and rats, rooting by feral pigs, erosion and the possible loss of native pollinators.

Recovery Objective: Downlist to threatened status.

Recovery Criteria: These species may be downlisted when there are a minimum of three reproductively separate populations on the island of Kaua'i. Each population must be naturally self-sustaining through the production of seeds, seedlings and mature plants, and large enough to insure long-term maintenance of genetic diversity.

Actions Needed:

1. Secure habitat of current populations and manage threats.
2. Conduct research essential to conservation of the species.
3. Expand current population numbers.
4. Establish new subpopulations.
5. Validate and revise recovery objectives.

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

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1993	0	40	0	0	0	40
1994	256.25	492	16	0	0	764.25
1995	232.25	492	62	2	0	788.25
1996	63	492	185.5	49.5	0	790
1997	63	492	164	42	0	761
1998	63	492	204	34	0	793
1999	48	104	204	34	0	390
2000	48	104	176	34	0	362
2001	48	104	51	34	0	237
2002	48	104	51	34	0	237
2003	48	64	11	4	6	133
2004	48	0	11	4	6	69
2005	48	0	11	4	13	76
2006	48	0	11	4	0	63
Total	1061.5	2884	1157.5	279.5	25	5407.5

Date of Recovery: Downlisting to threatened should initiate in 2006, if recovery criteria are met.

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

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RECOVERY PLAN FOR THE WAHIAWA PLANT CLUSTER

PART I. INTRODUCTION

1. BRIEF OVERVIEW

The subjects of this recovery plan are Cyanea undulata C. Forbes (Campanulaceae), Dubautia pauciflorula St. John & G. Carr (Asteraceae), Hesperomannia lydgatei C. Forbes (Asteraceae), Labordia lydgatei C. Forbes (Loganiaceae), and Viola helenae C. Forbes & Lydgate (Violaceae), five species that occupy essentially the same ecosystem. Until recently little was known about the status of these five species that are known only from lowland wet forest and shrubland in the Wahiawa Drainage Basin, Waioli Stream Valley and Makaleha Mountains on the island of Kaua'i (Figure 1). Cyanea undulata was considered to be possibly extinct by Lammers (1990). Wagner et al. (1990) considered Hesperomannia lydgatei as being vulnerable and the remaining three species as endangered. All five species were added to the federal list of endangered species on September 20, 1991 (Federal Register volume 56, No. 183, pages 47695-47700). The effective date of the listing was October 21, 1991 (Herbst 1991). Critical habitat was not designated for these species at the time of ruling on the grounds that it was not prudent.

A recent intensive survey of the Wahiawa Drainage area (Lorence and Flynn 1991) yielded more precise distribution and population data for these taxa and revealed that all were still extant but rare. Numbers of individuals encountered by Lorence and Flynn (1991) in this survey are in Table 1. A second population of Hesperomannia lydgatei comprised of three individuals (Table 2) was discovered in the upper Waioli Stream Valley, Kaua'i, in December, 1991, and two of these individuals were subsequently killed by Hurricane Iniki in September, 1992. A second population of two L. lydgatei individuals in the Waioli Valley and a third

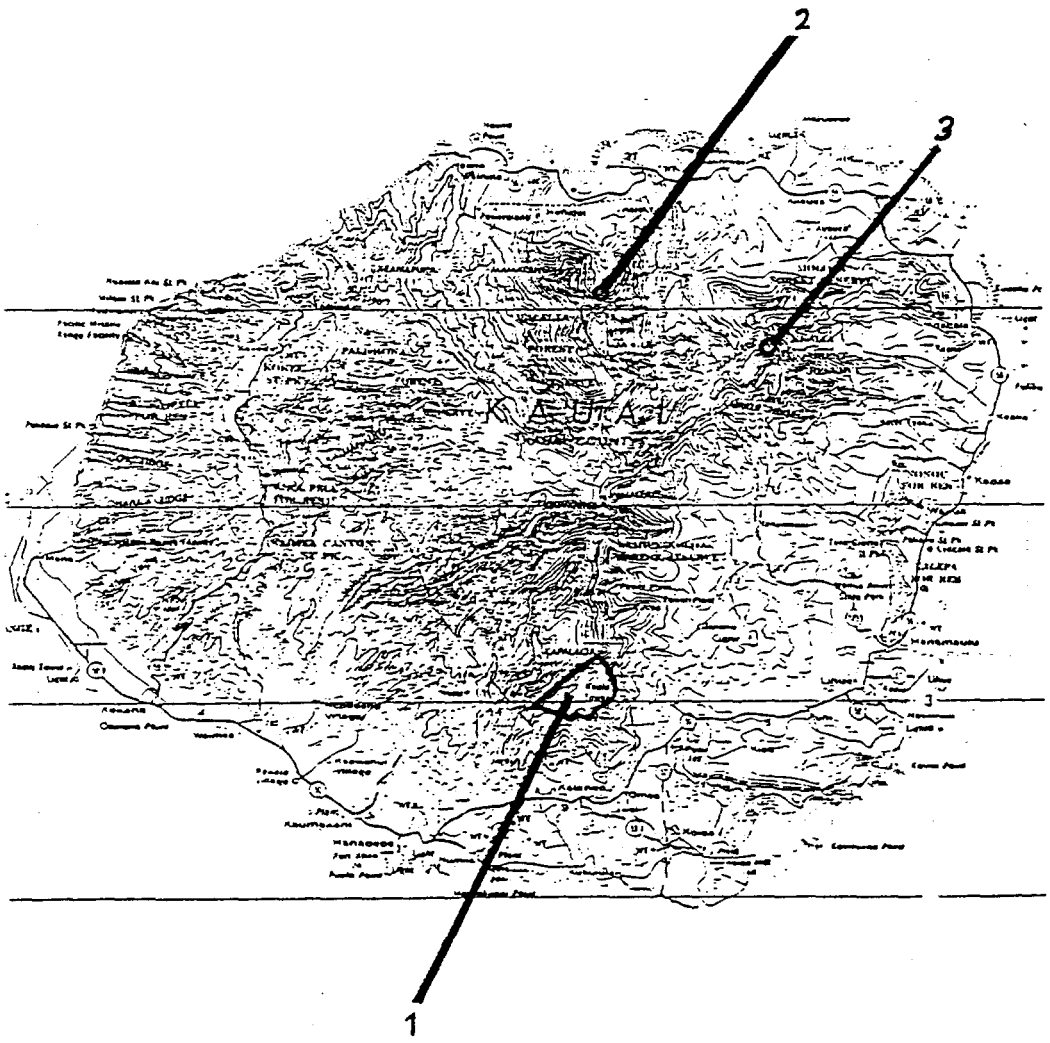

Figure 1. Map of Kaua'i showing locations of the Wahiawa Drainage (1), the Waioli Stream Valley (2) and the Makaleha Mountains (3).

Table 1. Total numbers of Endangered species encountered in the Wahiawa Drainage Basin, Kaua'i. Percent of total is given in parentheses. (Based on data from Lorence and Flynn 1991, and David Lorence, NTBG, personal observation, 7 October 1992.)

	Taxon	Numbers of Plants		
		Adult	Juvenile	Total
1.	Cyanea undulata	5(18)	23(82)	28(100)
2.	Dubautia pauciflorula	25(53)	22(47)	47(100)
3.	Hesperomannia lydgatei	195(69)	86(31)	281(100)
4.	Labordia lydgatei	7(100)	0(0)	7(100)
5.	Viola helenae	89(65)	48(35)	137(100)

Table 2. The current status of wild Kaua'i populations of Cyanea undulata, Dubautia pauciflorula, Hesperomannia lydgatei, Labordia lydgatei, and Viola helenae. Data from Lorence and Flynn (1991 & 1993), Steve Perlman (HPCC, personal communication 1992), and Kenneth Wood (personal communication 1992).

TAXON		POPULATION	NUMBER OF PLANTS
1.	Cyanea undulata	Wahiawa Drainage	28
2.	Dubautia pauciflorula	Wahiawa Drainage	47
3.	Hesperomannia lydgatei	Wahiawa Drainage	279
		Waioli Stream Valley	1
4.	Labordia lydgatei	Wahiawa Drainage	20
		Waioli Stream Valley	2
		Makaleha Mountains	1
5.	Viola helenae	Wahiawa Drainage	137

population, containing only one individual, in the Makaleha Mountains were discovered in December, 1992, (Lorence & Flynn 1993) and 13 additional individuals were discovered in Wahiawa in 1993 (Kenneth Wood, Hawaii Plant Conservation Center (HPCC), pers. comm.).

In the Wahiawa Drainage area, alien plants pose the greatest threat to these species, and feral pig damage presently poses a lesser threat. Both pigs and alien plants are major threats in the Makaleha Mountains (K. Wood, pers. comm. 1993). In addition, the present rarity of these species may be caused in part by low fecundity, slow regeneration, lack of suitable pollinators and seed dispersal agents, or low seed viability and germination levels. For example, Hesperomannia lydgatei produces an extremely low percentage of viable seed, and seed predation by insect larvae is also a problem. As the life history, reproductive biology, and ecology of all five species are virtually unknown, further research in these areas is necessary to understand why the species are currently so rare.

2. TAXONOMY

A. Cyanea undulata was described by C. Forbes (1912), who named it for the wavy appearance of the leaf margins. Forbes based this species on a collection he made in 1909 in "damp woods surrounding the Wahiawa swamp" and an earlier collection made by J. M. Lydgate in 1908, most likely from the same area. The endemic genus Cyanea is the largest genus of Hawaiian lobelioids and one of the largest genera of Hawaiian flowering plants, comprised of some 54 species, all endemic (Lammers 1990, Thomas Lammers, Field Museum of Natural History, pers. comm. 1991). *Haha* is a Hawaiian vernacular name for plants of this genus.

B. Dubautia pauciflorula was initially collected in 1909 by C. N. Forbes and in 1911 by J. M. Lydgate in the Wahiawa Mountains

just above a tributary of the Wahiawa Stream. The species was recollected in 1979 by S. Perlman along an unnamed western (Hanapepe) fork of the Wahiawa Stream and subsequently described as a new species by St. John & Carr (1981). Dubautia, a Hawaiian endemic genus of 21 species, is a member of the Madiinae tribe and is closely related to Argyroxiphium and Wilkesia (Carr 1985, Wagner et al. 1990). Hawaiian vernacular names for plants of this genus are *na'ena'e* and *kupaoa*.

C. Hesperomannia lydgatei was first collected in the Wahiawa Mountains by J. M. Lydgate in 1908. In 1909 C. N. Forbes recollected the species in the same area and published a description, naming it for Lydgate (Forbes 1909). Hesperomannia is a Hawaiian endemic genus of three species of shrubs and trees and the only representative of the tribe Mutisieae in Hawai'i. No vernacular names are known.

D. Labordia lydgatei was described by C. N. Forbes on the basis of collections made by the Reverend J. M. Lydgate in 1908 and himself in 1909. Forbes named this species in honor of its discoverer (Forbes 1909). Labordia is a Hawaiian endemic genus of 15 woody species related to Geniostoma (Sherff 1939, Wagner et al. 1990). The Hawaiian vernacular name for members of this genus is *kamakahala*.

E. Viola helenae was first collected in the Wahiawa Mountains by J. M. Lydgate in 1908 and described the following year by Lydgate and C. N. Forbes based on this same specimen (Forbes 1909). They named it for Lydgate's wife, Helen. J. F. Rock (1911) described a similar species from Lanai as a variety of Viola helenae, but the Lanai plant is generally regarded by botanists as a distinct species, V. lanaiensis (Rock) W. Becker (Becker 1916, St. John 1979, Wagner et al. 1990). Viola, a genus of 300 to 500 species widespread in mainly temperate regions of the world, is represented in Hawai'i by 7 endemic species, 6 of

which are the only woody members of this genus (Wagner et al. 1990). No vernacular names are known for this species.

3. SPECIES DESCRIPTION AND LIFE HISTORY

A. Cyanea undulata is an unbranched (or the stem is occasionally forked) shrub or subshrub 0.5 to 3.6 meters (m) (1.5 to 15 feet (ft)) tall with narrowly elliptic leaves 28 to 43.5 centimeters (cm) (11 to 17 inches (in)) long and 2.5 to 5 cm (1 to 2 in) wide, with wavy margins, a smooth upper surface, and fine rust-colored hairs covering the lower surface. The petiole (leaf stem) may be winged. The inflorescence is unbranched, 8 to 45 cm (3 to 17 in) long, and bears two to six flowers that are slightly curved, hairy, yellowish or greenish yellow and purplish at their base. Flowering material was collected from April to July. The fruit is an orange berry about 1.7 cm (0.7 in) long (Lammers 1990, Rock 1919, Wimmer 1943, D. Lorence and Timothy Flynn, NTBG, pers. obser. 1991). The Hawaiian lobelioid species, including the genus Cyanea, are generally believed to have adapted to pollination by native nectarivorous passerine birds, such as the Hawaiian "honeycreepers" (Lammers and Freeman 1986, Lammers et al. 1987). The long, tubular, slightly curved flowers of Cyanea undulata fit this model, but field observations are lacking. The fleshy orange fruits of this species are adapted for bird dispersal like other species of Cyanea.

Cyanea undulata is invariably found in the most pristine, undisturbed, and uninvaded sites, often on shady stream banks or steep to vertical slopes (Lorence & Flynn 1991) that are prone to erosion or landslides. Flowering occurs during the summer months, but adults seem not to flower every year (D. Lorence and T. Flynn, pers. obser. 1988-1991). Cyanea undulata appears to grow slowly, and consequently, it is likely to be adversely impacted by any feral animal disturbance or alien plant invasion of its habitat. Microhabitat conditions for seed germination and growth also may

be extremely specific. Specific details of the life history of this species, such as growth rates, age plants begin to flower, and longevity of plants, are unknown.

B. Dubautia pauciflorula is a somewhat sprawling shrub or erect small tree up to 3 m (10 ft) tall, with narrowly lance-shaped or elliptic leaves, broadest above middle, 8 to 21 cm (3 to 8 in) long and 1.2 to 3.2 cm (0.5 to 1.3 in) wide, and clustered toward the ends of the stems. There are 50 to 500 flower heads in a purplish, open, pyramidal inflorescence 8 to 30 cm (3 to 12 in) long and 6 to 30 cm (2 to 12 in) wide. Each head comprises 2 to 4 yellow florets 2.5 to 3.5 millimeters (mm) (0.1 to 0.15 in) long. The fruits are small, dry seeds (achenes) about 3 mm (0.1 in) long, with a crown of slender bristles (pappus) 2.5 to 3.5 mm (0.1 to 0.15 in) long. Flowering material was collected in August, September, and November and fruiting material in November (Carr 1985, St. John and Carr 1981, D. Lorence and T. Flynn, pers. obser. 1991). The tiny, 2 to 4 flowered heads distinguish this species from its relatives (Carr 1985).

Few details are known about the life history of any Dubautia species under natural conditions (Carr 1985). Certain species produce viable seed when self-pollinated (are self-fertile), although others fail to do so (are self-infertile) (Carr 1985, Gerald Carr, University of Hawai'i - Manoa, pers. comm. 1992). Low pollinator numbers resulting in reduced cross- pollination and consequently low numbers of viable seeds could explain the small population sizes. Because of their structure and small size, flowers of D. pauciflorula are presumably pollinated by small generalist insects, although field observations are lacking. The bristle-like pappus crowning the fruit probably represents an adaptation for wind dispersal. Very little is known about the life cycle of this species, including growth rates, longevity of the plants, and number of years the plants remain reproductive.

C. Hesperomannia lydgatei is a sparsely branched small tree 2 to 4 m (6.5 to 13 ft) tall with alternately arranged, lance-shaped or elliptic leaves that are 10 to 30 cm (4 to 12 in) long and 3.5 to 9 cm (1.4 to 3.5 in) wide, broader above the middle and paler beneath. The flower heads are in groups of 4 or 5 on slender stems and are clustered at the ends of branches and pendant when mature. The flower heads consist of 4 to 8 circles of overlapping bracts, the outer are purplish or brownish and the inner are silver, that surround the slender, tubular yellow florets, which are 2.3 to 2.5 cm (0.9 to 1 in) long. Flowering material was collected from July to November. Almost no mature fruits develop, and it is possible that Hesperomannia lydgatei is self-infertile and fails to set seed unless cross-pollinated with other individuals. The abortive fruits are crowned by a plume-like crown of light brown hairs 2 cm (0.8 in) long (Carlquist 1957, Degener 1932, Forbes 1909, Wagner et al. 1990, D. Lorence and T. Flynn, pers. obser. 1991).

The purple flower heads with long, tubular yellow florets of this species suggest pollination by long-tongued insects such as moths or butterflies (G. Carr, pers. comm. 1992), although field observations are required to confirm this. Absence of the appropriate pollinator(s) could be responsible for the observed lack of viable seeds. However, several seeds collected from plants at Waioli Stream Valley apparently possessed embryos and germinated successfully at the HPCC nursery (Kerin Lilleeng-Rosenberger, HPCC, pers. comm. 1992). Also, since 31 percent of the current population is made up of juvenile plants (Table 1), this species appears to be reproducing adequately in the wild.

The plume-like hairs crowning the fruit strongly suggests dispersal by wind, as in many members of the aster family. This species grows almost exclusively along streams, however, so dispersal by water currents is also likely. Specific details

regarding growth rates, age trees begin flowering in the wild, length of time they remain reproductive, and longevity of the plants are unknown.

D. Labordia lydgatei is a much-branched shrub or small tree 2 to 3 m (6.5 to 10 ft) tall with sparsely hairy, square stems. The opposite leaves are elliptic, often wider toward the tip, 5 to 10 cm (2 to 4 in) long, and 2 to 7 cm (0.8 to 2.8 in) wide, smooth above and with fine hairs on the lower surface. Intra-petiolar stipules are present. The inflorescences are produced at the ends of the stems and comprise 6 to 21 small, slender, tubular pale yellow flowers about 0.7 cm (0.3 in) long. Flower buds were collected in May and mature flowers in July. Green fruits were collected in October. The fruit is a small ovoid capsule with a short, blunt beak. At maturity it splits into two valves to expose the seed mass (Forbes 1916, Sherff 1939, Wagner et al. 1990). The small flowers and capsules borne on sessile inflorescences distinguish it from other members of the genus growing in the vicinity (L. hirtella, L. sp. aff. hirtella, and L. tinifolia var. wahiawaensis). The small pale yellow flowers are presumably fragrant like those of related species and are probably insect-pollinated. Seeds of most species of Labordia are embedded in a fleshy orange, aril-like mass, which is presumably an adaptation for bird dispersal.

This is the least abundant of the five species, with only 23 known plants in three widely scattered areas. Gene flow between these individuals is therefore unlikely. Immature fruits were seen on two of the plants and remnants of old fruiting bodies were seen on another, suggesting that the plants are self-fertile. Microhabitat requirements for seed germination and growth may be extremely specific. Virtually nothing is known about the life history or ecology of this species.

E. Viola helenae is a small, unbranched subshrub with an erect

stem 30 to 80 cm (1 to 2.5 ft) tall. The hairless leaves are clustered on the upper part of the stem, lance-shaped, 7.5 to 13 cm (3 to 5 in) long and 2 to 2.5 cm (0.8 to 1 in) wide. A pair of narrow, membranous stipules (leaf-like structures) 1.3 cm (0.5 in) long occurs below each leaf. The small, pale lavender or white flowers are less than 1 cm (0.4 in) long and are produced on stems about 4.5 cm (1.8 in) long, either singly or in pairs in the leaf axils. Flowers and immature fruits were collected in April, and mature fruits were collected in October. The fruit is a capsule 1.1 cm (0.5 in) long that splits open at maturity, releasing the pale olive brown seeds 1.5 mm (0.1 in) long (Fedde 1911, St. John 1989, Skottsberg 1940, Wagner et al. 1990, D. Lorence & T. Flynn, pers. obser. 1991).

Little is known about the life history and ecology of Viola helenae. Wagner et al. (1990) stated that the flowers are all chasmogamous (open at maturity for access by pollinators), none being cleistogamous (remain closed and self-fertilize in the bud) as in certain other violets. It is likely that its flowers require pollination by insects for seed set. Mature flowering plants do produce seed (D. Lorence, pers. obser. 1992), however, seed viability may be low and microhabitat requirements for germination and growth may be very specific. Seeds planted at the HPCC nursery failed to germinate (K. Leeling-Rosenberger, pers. comm. 1992), although they may not have been sufficiently mature when collected and violet seeds are often very slow to germinate (Derral Herbst, USFWS, pers. comm. 1993). The seeds are jettisoned when the capsule splits open, as in most species of the genus (D. Lorence and Flynn, T. pers. obser. 1991).

This single-stemmed woody violet seems to grow and reproduce extremely slowly and is apparently very sensitive to disturbance. A previously known population on the bank of a tributary no longer exists; the plants presumably died out after the canopy was disturbed by Hurricane Iwa in 1983 and subsequently invaded by

alien species (D. Herbst, pers. comm. 1991).

Two small populations of Viola helenae were found growing on the windward side of a windswept, exposed ridgetop among stunted Dicranopteris, an unlikely habitat for this species. The plants are atypically small for V. helenae, and further study is required to determine if they are conspecific or represent another taxon. Growth rates, the age plants begin flowering, their longevity, pollinators, and ecology are all unknown for this species.

4. HABITAT DESCRIPTION

As all five species were described from plants growing in the Wahiawa Drainage Basin and three species are essentially restricted to this region, it is useful to describe the habitat. Kaua'i is the oldest of the eight major Hawaiian Islands, with lavas dating from about 5.6 to 1.42 million years (Stearns 1966). Because of its great age and relative isolation, Kaua'i harbors one of the highest levels of floristic endemism in the Hawaiian Archipelago. One particularly interesting area is the Wahiawa Drainage Basin (herein referred to as the Wahiawa Drainage) in the Lihue-Koloa Forest Reserve, located in the Koloa District of southern Kaua'i. Once referred to as the Hi'i Mountains, this area harbors one of the oldest and most diverse wet communities in the islands, as well as a permanent stream system and the only low elevation bog in Hawai'i.

Characterized by rugged, mountainous terrain, this bowl-shaped, roughly triangular area is bounded on the north by Mt. Kapalaoa (3,310 ft or 1,009 m), on the southeast by Mt. Kahili (3,089 ft or 941 m), and on the southwest by Pu'u Au'uka (2,270 ft or 692 m). The Lihue-Koloa District boundary runs from Mt. Kapalaoa to Mt. Kahili, and the Waimea-Koloa District boundary runs from Mt. Kapalaoa to Pu'u Au'uka. The area has a maximum length of about 3.8 kilometers (km) (2.3 miles (mi)) and a basal width of about

1.7 km (1.0 mi). The land within the triangle is owned by the McBryde Sugar Company, Ltd.

Geologically the area is a mixture of older lavas of the Napali formation (5.72 to 4.47 million years old) and younger ones of the Koloa volcanic series (1.42 million years old) (Stearns 1966). Lying in the middle of the triangle is an area of poor drainage, the Wahiawa Bog (also known as Kanaele or "the bog" in Hawaiian). With an elevation of only 620 to 640 m (2,033 to 2,100 ft), it is unique in being the only true low elevation bog in Hawai'i. The soils are classified as Hulua Gravely Silty Clay Loam and Ko'olau Silty Clay, both types characteristic of the areas rough mountainous land (Foote et al. 1972).

The area is often cloud-filled and windy. An important watershed, this drainage system is the source of the Wahiawa Stream, whose estuary is near Weli Point between Port Allen and Numila on the south shore of Kaua'i. It also supplies water to the Alexander Reservoir, owned by the McBryde Sugar Company. The rainfall data available for the area are derived from records kept for rain gauges at the Wahiawa Bog and the Alexander Reservoir (rain station Alexander Reservoir SKN 983.00), which is located along the lower boundary of the study area at 640 m (2,100 ft) elevation. Over a 53 year period from 1930 to 1983, the reservoir averaged 192.6 cm (85.6 in) of rain per year. Wahiawa Bog averaged 355.3 cm (157.9 in) of rain per year over a 69 year period from 1901 to 1973 (National Oceanic and Atmospheric Administration 1980). The average rainfall likely continues to increase as the elevation increases toward the upper reaches of the Wahiawa Drainage.

The Wahiawa Mountains comprise a region of high floristic endemism on Kaua'i. Most of the area is covered by Lowland Wet Metrosideros Forest and Lowland Wet Metrosideros Shrubland (Gagné & Cuddihy 1990), with Antidesma platyphyllum, Syzygium

sandwicensis, and Dicranopteris linearis as the main codominants. The wet forest is best developed in valleys, and the shrubland occurs on windswept slopes and ridgetops. Certain poorly drained areas support a boggy vegetation classified as Lowland Wet Mixed Community (Gagné & Cuddihy 1990), best developed in the Wahiawa Bog itself. The majority of plant communities in the area are primary in nature and have suffered little direct disturbance by man. One plant species that is proposed for listing as endangered, and seven plant species which are candidates for listing (Table 3) also occur in this habitat. Encroachment by invasive alien plant species is apparent over much of the area, however, and feral pigs are present.

The habitat of Hesperomannia lydgatei and Labordia lydgatei in the upper Waioli Stream Valley below Namolokama Mtn. at 400 m (1,300 ft) elevation consists of lowland rain forest with Metrosideros and Dicranopteris dominant (D. Lorence, pers. obser. 1992). This is similar to the species' habitat in the Wahiawa Drainage and the L. lydgatei habitat in the Makaleha Mountains.

An extensive botanical survey of the Wahiawa Bog and vicinity was conducted between December 1990 and July 1991 by Lorence and Flynn (1991). An additional survey trip was made on October 7, 1992. Detailed observations as to location, habitat, and threats were made each time an endangered species was encountered. Reproduction was assessed by noting whether the plants were juveniles or adults (Table 1). Invasion by alien plant species and feral pigs was also assessed.

Table 3. List of rare plant species associated with the Wahiawa plant cluster populations.

Scientific name	Status
Melicope quadrangularis*	Proposed Endangered
Botrychium subbifoliatum	C2 Candidate
Chamaesyce remyi var. remyi	C2 Candidate
Hedyotis tryblium	C2 Candidate
Joinvilles ascendens var. ascendens	C2 Candidate
Lysimachia daphnoides	C2 Candidate
Melicope paniculata	C2 Candidate
Phyllostagia helleri	C2 Candidate

Proposed Endangered = has been formally proposed for listing as an endangered species.

C2 Candidate = a species for which listing may be warranted, but not enough information exists to develop a listing proposal.

* Recovery of this species will be addressed in the Kaui Plant Cluster Recovery Plan.

5. HISTORIC RANGE AND POPULATION STATUS

It is impossible to ascertain how abundant these five species were prior to European contact, as no written records exist. Furthermore, none of the naturalists in the 1800's mentioned these species, and no herbarium specimens are known from this period. Historically, all five species were known only from the Wahiawa Drainage Basin where they were initially collected by J. M. Lydgate and C. N. Forbes between 1908 and 1911. The original publications provided no information as to their abundance or population status (Forbes 1909, 1912, St. John and Carr 1981). Subsequent information regarding their population status was gathered from herbarium label data at Bishop Museum (BISH) and the National Tropical Botanical Garden (NTBG) herbaria, the Heritage Program of The Nature Conservancy of Hawai'i (TNCH) (Joel Lau, TNCH, pers. comm. 1992), and pers. comm. with field botanists and other individuals familiar with these species (listed in Appendix A).

A. Cyanea undulata. This species was described from two original collections: the type was gathered in 1909 by Forbes in "damp woods surrounding the Wahiawa swamp," and another collection (now lost) was made in the same area by Lydgate in 1908 (Herbst 1991). This species was collected in 1988 by T. Flynn, who observed a single population of three to four plants growing along the bank of a tributary of the Wahiawa Stream at about 700 m (2,300 ft) elevation (Flynn 2983, in NTBG herbarium, T. Flynn, pers. comm. 1991). This was its status at the time of Federal listing, unknown to Lammers (1990), who stated it was probably extinct.

B. Dubautia pauciflorula. The original Forbes and Lydgate collections were made in 1909 and 1911 in the "Wahiawa Mountains, ridge just above tributary of the Wahiawa Stream" (Herbst 1991). This species was recollected in 1979 by S. Perlman (specimen at BISH) in the "Wahiawa Mts., on an East facing ridge of 10° slope 30 m (98 ft) from an unnamed left (Hanapepe) fork of Wahiawa Stream" at about 700 m (2,300 ft) elevation. This same population of about 30 plants was known at the time of listing (Herbst 1991, Steve Perlman, Hawai'i Plant Conservation Center (HPCC), pers. comm. 1992).

C. Hesperomannia lydgatei. The original Forbes and Lydgate collections of this species were also made in the Wahiawa Mountains in 1908 and 1909. C. H. Lamoureux recollected it in 1955 (Herbst 1991). It was noted to be, "Rare and local in dense wet forest, 600 to 750 m, only along Wahiawa Stream, Kaua'i," by Wagner et al. (1990). In listing the species as endangered, Herbst (1991) stated that 4 populations were known, comprising between 154 and 192 plants of various sizes, all located along or close to the Wahiawa Stream and its tributaries.

D. Labordia lydgatei. Three collections of this species were originally made in 1908 and 1909 by Lydgate and Forbes.

Subsequent collections were made by S. Perlman in 1987 and by W. L. Wagner and C. Imada in 1988. At the time of listing, Labordia lydgatei was known from one population of about three plants located along one of the tributaries of the Wahiawa Stream at approximately 700 m (2,300 ft) elevation (Herbst 1991).

E. Viola helenae. The original publication describing Viola helenae gave no information on its historic range or population status (Forbes 1909), nor did subsequent publications. Woolliams (1972) stated that in 1971 there were, "Probably fewer than 30 plants on Kaua'i," near the Wahiawa Bog, although the area was by no means exhaustively surveyed (Keith Woolliams, Waimea Arboretum, pers. comm. 1992). Wagner et al. (1990) said it was, "Extremely rare, known only from a small area, elevation 610 m, along Wahiawa Stream, Kaua'i." At the time of listing this violet was known from 2 populations along either branch of the Wahiawa Stream, totalling about 13 plants.

6. CURRENT RANGE AND POPULATION STATUS

The survey carried out by Lorence and Flynn (1991) in the Wahiawa Drainage area significantly increased our knowledge of the distribution, habitat, and population structure and sizes of all five species. A trip into the area on October 7, 1992 revealed additional plants of all species except Viola helenae. The total known wild numbers of these five species in the Wahiawa Drainage area as of October 1992 are given in Table 1. In addition, a second population of Hesperomannia lydgatei consisting of three individuals was found in the upper Waioli Stream Valley, Kaua'i in December, 1991 (Table 2). Two of these plants were killed and the third badly damaged by hurricane Iniki in September, 1992.

Maps or descriptions of the exact locations of known individuals will not be included in this Plan due to the possibility that vandalization or unauthorized collection could be encouraged by

the public release of this information. The U.S. Fish and Wildlife Service will consider requests for Appendix B, which contains site specific maps, on a case-by-case basis.

A. Cyanea undulata. As summarized in Table 1, a total of 28 plants, 5 adults and 23 juveniles, are known from 7 localities in the Wahiawa Drainage (Appendix B). Adults of Cyanea undulata generally occur as scattered individuals, although several juveniles occasionally are found growing together. The high juvenile to adult ratio indicates that this species is reproducing, but the low total number suggests that regeneration is extremely slow.

B. Dubautia pauciflorula. Forty-seven individuals of this species, 25 adults and 22 juveniles, are known from four localities in the Wahiawa Drainage (Table 1 & Appendix B). The majority of plants (39) were confined to the original type locality in a small Valley near a stream, where almost half the population consisted of juveniles despite heavy infestation by strawberry guava (Psidium cattleianum). The three other sites were along streams where guava invasion is also a serious problem. All individuals were sterile during the survey period. Nearly equal numbers of adults and juveniles indicate regeneration is occurring, albeit slowly.

C. Hesperomannia lydgatei. This is by far the most abundant of the five species encountered (Table 1), with 281 individuals, 195 adults and 86 juveniles recorded at eight localities in the Wahiawa Drainage (Appendix B). Judging by the substantial number of juveniles, this species seems to be regenerating well. In December 1991 a disjunct population of three plants was located in the upper Waioli Stream Valley below Namolokama Mountain (Appendix B) at 400 m (1300 ft) elevation (S. Perlman 12448, specimen in National Tropical Botanical Garden herbarium, NTBG). Two of these plants were killed and the third damaged by hurricane Iniki in

September, 1992. Further field work is needed in the Waioli Stream Valley to determine the vigor of this individual and to survey for others which may be in the area.

D. Labordia lydgatei. This is the rarest of the 5 species, with 23 individuals, all adults, known from 4 localities in the Wahiawa Drainage, the Waioli Stream Valley and Makaleha Mountains (Table 1 and Appendix B). A juvenile possibly representing this species was seen, but it was not counted because identification was uncertain. Five of the adults were clearly referable to this species, but two other adults had flowers and leaves approximately 50 percent larger than normal for Labordia lydgatei and thus approach L. hirtella H. Mann, a common species in the Wahiawa area and one that sets seed abundantly. The taxonomic status of these latter two plants needs to be investigated further. Of the three plants sighted by S. Perlman in 1987 and W. L. Wagner and C. Imada in 1988, two were not relocated (Lorence and Flynn 1991). The Waioli population consists of only two plants, and a single individual is known from the Makaleha Mountains.

E. Viola helenae. Five populations of this species comprising 137 individuals, 89 adults and 48 juveniles, all from the Wahiawa Drainage (Appendix B). Three populations of this species occur on stream banks, valley bottoms, or slopes, usually in light to moderate shade. Two of these were in relatively undisturbed, uninvaded areas, and one was moderately invaded by alien species. Two other small populations were growing on the windward side of a windswept, exposed ridgetop among stunted Dicranopteris, an unlikely habitat for Viola helenae. Research may be needed to determine if these individuals are conspecific or represent another taxon.

7. REASONS FOR DECLINE AND CURRENT THREATS

A. Alien plants. Alien plant species pose the most severe threat

to the Wahiawa, Waoili and Makaleha ecosystems, as they compete with native species for light, water, space, and nutrients. Aliens such as the strawberry guava, Psidium cattleianum, a member of the Myrtaceae family, may exude allelopathic substances toxic to native species (Tunison 1991).

The two most serious alien plants in the areas are as follows: (1) Melastoma candidum (no common name in Hawai'i), a member of the Melastome family, is a vigorous invader of the low shrubland on flats surrounding the bog, where it forms dense, impenetrable shrubs 2 to 4 m (6.6 to 13.1 ft) across. This aggressive weed is becoming established along many of the streams and on slopes, flats, and ridges throughout the area. It prefers clearings and is rarely found in dense shade. Its fruits are presumably bird and/or wind dispersed and contain numerous small seeds. (2) The red-fruited strawberry guava, Psidium cattleianum var. cattleianum, is undoubtedly the worst invader, particularly in valley bottoms and along streams, where it chokes out most other species. It already forms dense pole forests in many such areas, and large, tall individuals with diameters of 15 to 20 cm (6 to 8 in) are frequently seen. It is a particular threat to Dubautia pauciflorula, Hesperomannia lydgatei and Viola helenae. Strawberry guava is readily spread by birds and pigs and easily becomes established in the shade of pristine native forest. It regenerates rapidly in its own shade and prevents the regeneration of virtually all native species, eventually choking them out (Lorence & Sussman 1986, 1988, Tunison 1991). A few individuals of the yellow-fruited strawberry guava, Psidium cattleianum var. lucidum, were seen at lower elevations along the main stream, but this variety is much more abundant along the jeep road to the south. It is apparently not as invasive as the red-fruited variety in Hawai'i.

The following two potentially serious weed species are not yet widespread, but further encroachment should be prevented. The

downy or rose myrtle, Rhodomyrtus tomentosa (Myrtaceae), is a densely branching shrub. It is a serious pest in adjacent areas of southern Kaua'i just east of the Wahiawa Mountains from Kahili Mountain Park to Kilohana Crater, where it forms dense, impenetrable stands. Only 10 to 15 individuals of this invasive species were encountered (and destroyed) in open, shrubby flats and also around the main bog. Clearly, its establishment in the area should be prevented. Koster's Curse, Clidemia hirta var. hirta (Melastomataceae), is one of the most serious weeds in Hawai'i (Tunison 1991). It is currently established along the jeep road to Mt. Kahili, but it has the potential of spreading throughout the entire region. The State is attempting to check its spread with biological control measures such as insects (Anon. 1987) and fungi (Tunison 1991). It is uncertain just how effective these organisms have been, as the Wahiawa plants appear to be flowering and fruiting vigorously and are invading the forests flanking the jeep road. Only several individuals of the paperbark tree, Melaleuca quinquenervia (Myrtaceae), were seen, presumably spread from forestry plantings. This species is a potentially serious invader (Geiger 1981) and should be eradicated immediately.

The remaining alien plant species are generally much less aggressive as invaders, or else are not currently widespread. The subshrub Stachytarpheta dichotoma (Verbenaceae), known as *owi* or *oi* in Hawaiian, is mostly restricted to edges of streams and paths, where it is occasionally common. The thimbleberry, Rubus rosifolius (Rosaceae), is occasional to common locally on shady, moist stream banks and slopes in many areas, where it occurs as scattered individuals or in small patches. Although generally not very invasive, it is well established in some areas and can be expected to displace native species to a certain degree. In addition, it is a vigorous colonizer of landslides (D. Lorence, pers. obser. 1992). Three herbaceous Asteraceae species, Elaphantopus mollis (no common name), Erechtites valerianifolia

(no common name), Youngia japonica (Oriental hawksbeard), and the shrub Pluchea carolinensis (sourbush; Asteraceae) occur as scattered individuals or small populations, mainly in clearings and light gaps. Five species of alien grasses (Poaceae) were noted: Oplismenus hirtellus (basketgrass), Paspalum conjugatum (Hilo grass), Paspalum urvillei (Vasey grass), Sacciolepis indica (Glenwood grass), and Setaria gracilis (yellow foxtail). Of the five, the two species of Paspalum are the most invasive, forming extensive stands along streams and paths in some areas. The introduced fern Depparia petersenii (synonym Diplazium japonicum) (no common name; Athyriaceae) occurs on stream banks and gulches. One individual of the Australian tree fern, Cyathea cooperi (Cyatheaceae), was seen. This species is a potentially serious invader of Hawaiian wet forests (Medieros et al. 1992).

It is important to remember that alien organisms including weeds, insects, and pathogens are being introduced into Hawai'i almost continuously. Certain species that may become naturalized in Hawai'i in the future could threaten wild populations of these endangered species.

B. Feral animals. At present feral animals appear to pose a significant threat to the Makaleha area (K. Wood, pers. comm. 1993) and slight to moderate feral pig damage was noted in four areas in the Wahiawa Drainage, and in the Waioli Stream Valley (D. Lorence and T. Flynn, pers. obser. 1991). Rooting was primarily confined to moist, shady valley bottoms along streams, the habitat of Hesperomannia, Dubautia, and Viola. Pigs could become a severe problem should more animals move into these areas. There were no signs of goats or other ungulates. Rats were observed on several occasions and are harmful as seed predators and herbivores.

C. Landslides and erosion. Although most slopes in these areas are not excessively steep and are usually clothed with vegetation, there is evidence of past landslides in the area, especially after

Hurricane Iniki (D. Lorence, pers. obser. 1991-1992). Landslides clearly pose a threat to populations of these species growing on relatively steep slopes or in valley bottoms. In addition, Cyanea undulata, Dubautia pauciflorula and Viola helenae most frequently occur on steep soil banks or stream banks that are prone to erosion and undercutting.

D. Disease and insect predation. The impact of various diseases and insects on these five species has not been adequately studied. However, no obvious diseases or insect predation was noted, with the exception of Hesperomannia lydgatei, where insect larvae were often found in the fruiting heads. Seed predation by rats was not observed but is a possibility, as rats were observed in the area (D. Lorence and T. Flynn, pers. obser. 1991). In addition, rats feed on the bark of Clermontia shrubs and the stems of certain Cyanea species on Kaua'i (D. Lorence and T. Flynn, pers. obser. 1991-1992). Introduced slugs have also been observed feeding on stems and leaves of Cyanea plants that had been previously damaged by rats and hurricane winds (D. Lorence, pers. obser. 1992). Herbivory by rats and slugs therefore are potential threats to Cyanea undulata.

E. Lack of dispersal, germination and pollination agents. Two of the species, Cyanea undulata and Labordia lydgatei, have fruits obviously adapted for bird dispersal. Passage of these seeds through a bird's gut may be necessary to insure their germination, and pollination may be inhibited by a lack of bird or native insect pollinators.

It has been suggested that widespread extinctions of passerine birds may be causing declines in Hawaiian lobelioids that have depended on these birds for pollination (Lammers & Freeman 1986). Approximately half of the historically known nectarivorous passerine birds in Hawai'i are extinct, and serious population declines threaten many of the other species (Lammers et al.

1987). Individuals or occasionally several of the following native birds were observed in the Wahiawa Drainage: 'Elepaio (Chasiempis sandwichensis), 'Apapane (Himatione sanguinea), Koloa (Anas wyvilliana), and Pueo (Asio flammeus sandwichensis). Introduced birds were also rare and included the Japanese white-eye (Zosterops japonicus) and Shama thrush (Copsychus malabaricus) (D. Lorence, T. Flynn, S. Perlman, and K. Wood, pers. obser. 1990-1992). Recent observations by Lammers et al. (1987) indicate that any Hawaiian lobelioids that are not autogamous (i.e., do not set seed through self-pollination) formerly depended on native birds for pollination. Such plants may benefit from the Japanese white-eye, a bird species introduced in Hawai'i and sighted in the Wahiawa Drainage at least once (K. Wood, pers. comm. 1992). The conspicuously low numbers of native birds in the Wahiawa Drainage may have a negative impact on the reproduction of these species.

F. Land conversion. Past clearing of lowland wet forest on Kaua'i for agricultural uses may have contributed to the endangerment of these five species. At present this activity is not a threat at any of the sites.

G. Overcollection. Overcollection for scientific or horticultural purposes currently poses little threat to the existence of these five species, as most are difficult to find, inconspicuous, and extremely difficult to propagate and grow. Also, they are probably unknown to all but a few botanists and conservationists. Native gathering rights claims and proposed new rules to relax cultivation restrictions may increase this threat.

H. Hurricanes. On September 11, 1992 Hurricane Iniki passed directly over Kaua'i with winds gusting up to 175 miles per hour. Considerable damage was inflicted on the native forests in many parts of the island (S. Perlman & K. Wood, pers. comm. 1992). A small part of the Wahiawa Drainage was surveyed on October 7,

1992, to assess hurricane damage to populations of the five endangered species known to occur there (D. Lorence, pers. obser. 1992). Damage to the vegetation varied from slight to severe depending on exposure to the winds, and several land slides had occurred. In this very limited survey at least one or several individuals of each endangered species had been severely damaged or destroyed by winds that uprooted the plants or snapped the main stem, falling trees or branches, or landslides. In the Waioli Stream Valley, two of three Hesperomania lydgatei individuals were destroyed by the storm. A complete survey of all known populations and individuals is needed to quantify the amount of damage these five species suffered from Hurricane Iniki. Hurricane damage is clearly a serious threat, but one that is difficult or impossible to manage.

8. CONSERVATION EFFORTS

By organization

1. Federal actions. The U. S. Fish and Wildlife Service listed all five taxa as endangered species in 1991 (Herbst 1991). Listing did not include critical habitat.

2. State of Hawai'i actions. Because these five taxa are federally listed species, the State of Hawai'i also officially lists them as endangered species under Chapter 195D of the Hawai'i Revised Statutes. The populations in the Wahiawa Drainage occur on privately owned land and are consequently not managed by the State of Hawai'i, although all five species are afforded full protection under Hawaiian law. The newly-discovered population of Hesperomannia lydgatei in the Waioli Valley is included in the Halalea Forest Reserve, an area managed as Conservation District Forest Land under the jurisdiction of the State of Hawai'i, Division of Forestry and Wildlife. No active management of Hesperomannia has been undertaken to date.

3. Private Landowner actions. The Wahiawa Drainage is an important watershed and source of the Wahiawa Stream. It also supplies water to the Alexander Reservoir which, together with most of the Drainage, is owned by McBryde Sugar Company. McBryde does not actively manage the area's vegetation.

4. Efforts by botanical gardens to propagate or preserve. Information in this section was obtained from propagation records and discussion with staff at the following botanical gardens in Hawai'i: Honolulu Botanical Gardens (Scot Medbury, pers. comm. 1992); Lyon Arboretum (Ray Baker, personal communication 1992); National Tropical Botanical Garden; Waimea Arboretum and Botanical Garden (Keith Woolliams, pers. comm. 1992).

A. Cyanea undulata. No *in situ* or *ex situ* conservation efforts have been attempted. Certain other species of Hawaiian Cyanea have been successfully germinated and grown to seedling stage (Duval 1992, K. Lilleeng-Rosenberger, pers. comm. 1992).

B. Dubautia pauciflorula. In 1991 HPCC staff collected 166 seeds for propagation, although no seeds have germinated to date (K. Lilleeng-Rosenberger, pers. comm. 1992). Cuttings of Dubautia pauciflorula and many other species of Dubautia were successfully rooted in perlite and grown in a growth chamber at the University of Hawai'i (Carr 1979, G. Carr, pers. comm. 1992). Some species, including Dubautia pauciflorula, actually flowered. All plants of these Dubautia species died after outplanting on Oahu at the Waimea Arboretum, Haleiwa (K. Woolliams, pers. comm. 1992), and the Lyon Arboretum, Honolulu (R. Baker, pers. comm. 1992). No *in situ* conservation efforts have been attempted to date.

C. Hesperomannia lydgatei. Examination of numerous fruiting heads of plants from the Wahiawa area revealed that virtually all of the seeds were aborted. Efforts to germinate seeds from Wahiawa plants at the National Tropical Botanical Garden (K. Leeling-Rosenberger, pers. comm. 1992) and at the Honolulu Botanical Gardens (S. Medbury, pers. comm. 1992) have failed. Several viable seeds were collected from a plant in Waioli Stream Valley, although most of the seeds were insect-eaten. Five seeds were planted at the National Tropical Botanical Garden's Hawai'i Plant Conservation Center nursery, four of which germinated and are now at the seedling stage (K. Lilleeng-Rosenberger, pers. comm. 1992). No *in situ* conservation efforts have been attempted to date.

D. Labordia lydgatei. Conservation efforts have not been attempted, either *in situ* or *ex situ*. Attempts to cultivate other species of Labordia at Waimea Arboretum have all failed (K. Woolliams, pers. comm. 1992).

E. Viola helenae. In 1971 an attempt was made to propagate Viola helenae *ex situ*, when six small plants were collected and brought to the National Tropical Botanical Garden on Kaua'i (Woolliams 1972). Two were placed on tree fern logs and the roots covered with sphagnum, and four were potted in soil. The plants were placed under mist for a few days, then transferred to a plastic case. Although one plant with buds actually flowered, all died within five months. In mid-1991 two lots of seeds (14 and 64 seeds, respectively) were collected by HPCC staff for propagation at NTBG, but no germination has resulted to date, possibly because the seeds were not mature enough (S. Perlman, pers. comm. 1992). Germination in a cool house should be attempted. Viola chamissoniana ssp. chamissoniana, another Hawaiian endemic, has been successfully grown from seeds in the HPCC nursery

(K. Lilleeng-Rosenberger, pers. comm. 1992). No *in situ* conservation efforts have been attempted to date for V. helenae.

5. Research activities. Beyond the limited propagation trials mentioned above, virtually no research has been conducted on any of these species.

PART II. RECOVERY

1. OBJECTIVES

This recovery plan presents a framework detailing the steps necessary to ensure the long-term survival of the five Wahiawa species under natural conditions. Objectives are to: (1) stabilize existing populations; (2) downlist to threatened status; and, (3) completely remove the Federal protective status. Although implementation of this plan should result in recovery of all five species, special emphasis should be given to the rarest species first (see Table 2) in the following order: Labordia lydgatei, Cyanea undulata, Dubautia pauciflorula, Viola helenae, and Hesperomannia lydgatei.

1. Stabilization of existing populations. The first objective of this plan is to prevent the decline of these five species by stabilizing their existing populations. To be considered stable, existing populations must be freed from competition with alien plant species and protected from feral pigs and seed predators. It is crucial that the species be able to complete their entire life cycle within the area. This objective can be met by controlling threats from alien plant species, seed predators, and feral pigs. Selective removal of encroaching alien plants should be conducted where necessary. Pig exclosures should be built where appropriate (e.g., around the main population of Dubautia pauciflorula) and unlimited pig hunting should be encouraged. As many genotypes as possible from within the populations must be collected and backed up by stored germplasm and plants growing in safe localities such as nurseries or botanical gardens. These back-up plants must be first-generation outcrossed progeny from the wild plants and clones from existing plants. Material propagated vegetatively or by micropropagation may be used where appropriate, if it does not adversely impact the wild plants.

2. Downlisting to threatened status. The five listed Wahiawa species can be considered for down-listing to threatened status once: (1) the population of each species has been stabilized by removal of threats; (2) each species occurs in at least three populations, each with at least 250 reproductive individuals; and (3) the full genetic diversity of each population is backed up as living and stored material at one or more nurseries or botanical gardens.

These populations should be as genetically diverse as possible, and if artificially established, they must be within the historical range of the species. Each species should be able to reproduce naturally, i.e., complete its life cycle within the population areas, with percentages of adults, juveniles and seedlings necessary for long-term maintenance of population numbers and genetic diversity. This objective is considered to be biologically reasonable and attainable, but it should be re-evaluated as new information becomes available.

3. Delisting. The target for delisting includes locating, or establishing if necessary, at least 2 additional wild populations, for a total of at least 5 reproductively stable populations, each with at least 250 reproductive individuals, per species. These populations should be stable over an estimated ten year period. Further field exploration on Kaua'i is likely to yield additional populations of at least some of these species. If more populations are discovered, they should be augmented to reach the target size. If new populations are established, they should have optimum genetic composition and be within the historical range of the species. All five populations should be unmanipulated and able to sustain themselves indefinitely without such human intervention as fencing and alien plant control.

The numbers of individuals and populations given in the above objectives were chosen, based on our current understanding of

these species, they should provide for the maintenance of the majority of the genetic diversity of each species, and provide some assurance that a single catastrophic event will not destroy all members of a species. Much basic research on the life history and reproductive biology of all five species needs to be conducted in order to ascertain whether these objectives are indeed valid. This recovery plan should, therefore, be modified to incorporate any new information as it becomes available.

2. STEP-DOWN NARRATIVE

1. Secure and manage existing populations.

Preservation of the existing habitat at the Wahiawa Drainage, Waioli Stream Valley and Makaleha Mountains is essential to stabilize known populations and prevent the decline of these species, as all the known genetic diversity for the five species occurs here. This task involves managing the Wahiawa Drainage and Waioli Stream Valley habitats to protect the remaining wild plants of these five species until their populations can either expand naturally or be artificially increased by outplanting.

11. Negotiate a cooperative agreement with McBryde Sugar Co., Ltd for management of Wahiawa Drainage.

A long-term agreement spelling out precisely what actions are necessary to protect the habitat should be negotiated with the landowner. Methods to accomplish this include, but are not limited to; the development of conservation easements, cooperative agreements, leases, or fee purchases.

12. Negotiate an agreement with the State of Hawaii for management of populations on State land.

The State of Hawai'i, which manages the upper Waioli Stream Valley and the Makaleha Mountains as part of the Halalea Forest Reserve, should also agree to implement the management objectives outlined in task #14.

13. Manage Wahiawa populations.

Active management of these populations is essential to their survival.

131. Control ungulates and other herbivores.

Herbivores must be controlled where necessary. Fencing is necessary to protect some populations, and a control program should be established.

1311. Construct and maintain fencing.

All populations under threat from feral ungulates should be fenced for protection. The fenced area should be, at a minimum, large enough to accommodate the augmentation activities outlined below and should be periodically maintained.

1312. Establish a feral ungulate control program.

A feral ungulate control program is essential for the preservation and recovery of these species. Unlimited hunting of pigs should be encouraged, and other methods of control, such as snaring and drift fencing should be considered.

1313. Control seed predation by insects.

Insect predation on seeds of Hesperomannia lydgatei (and other species if necessary) should be controlled through bagging of seed heads (which would make artificial pollination necessary), use of EPA approved and carefully tested insecticides, or other appropriate measures.

1314. Control rats as necessary.

Rats may need to be controlled, particularly near Cyanea undulata populations, if indicated by research and monitoring.

132. Control alien plants.

Clearly, control of the two worst alien plant species, Psidium cattleianum and Melastoma candidum, is an urgent management priority for the Wahiawa Cluster species. If steps are not taken to control their spread, the pristine areas that remain will quickly be overrun by these insidious pests, and populations of the five endangered species in the area will almost certainly decline further, possibly resulting in their extirpation.

1321. Schedule periodic weedings to remove alien plants.

Selective weeding of aliens may prove temporarily effective for small populations and individuals. Further incursion by the alien weeds Rhodomyrtus tomentosa, Melaleuca quinquenervia, and Clidemia hirta should be prevented by weeding or other control measures before their establishment also becomes a severe problem. Weeding must be done with utmost care, as it carries with it the risk of further disturbance of the fragile habitat and opening of areas for weed establishment and erosion.

1322. Monitor alien plant species.

At present, control measures for the other less common alien species are not deemed necessary, as

they do not appear to pose serious threats. However, populations of all weeds should be monitored periodically, and included in control efforts if they become a threat to the endangered taxa.

1323. Implement biological control of alien species.

Based on the results of research task # 21, biological control of alien plants should be implemented as soon as possible.

133. Consider slope stabilization.

Cyanea undulata, Dubautia pauciflorula, Labordia lydgatei and Viola helenae individuals occur on steep slopes which are vulnerable to erosion and landslides. Stabilizing these areas may be warranted, given the critically low numbers of these species.

134. Implement cross-pollination as needed.

A program of cross-pollination should be conducted for those species suffering from inbreeding depression or self-infertility, as dictated by the outcome of task #23.

135. Map and monitor all individuals.

All individuals must be identified and monitored at least once annually. This monitoring effort should be extended to new individuals and populations as they are established. Maps of existing and new plants should be kept, as tagged plants are subject to vandalism. Use of Global Positioning System equipment may be helpful.

14. Manage State owned Waioli and Makaleha Mts. populations.

Active management of these populations is essential to their survival.

141. Control ungulates and other herbivores.

See narrative under task # 131.

1411. Construct and maintain fencing.

See narrative under task # 1311.

1412. Establish a feral ungulate control program.

See narrative under task # 1312.

1413. Control seed predation by insects.

See narrative under task # 1313.

1414. Control rats as necessary.

See narrative under task # 1314.

142. Control alien plants.

Clidemia hirta is the most serious alien weed species in Waioli Valley and other weed species in Waioli and the Makaleha Mts., especially Pluchea, Psidium and Melastoma (K. Wood, pers. comm. 1993) may need to be controlled.

1421. Schedule periodic weedings to remove alien plants.

See narrative under task # 1321.

1422. Monitor alien plant species.

See narrative under task # 1322.

1423. Implement biological control of alien species.

See narrative under task # 1323.

143. Consider slope stabilization.

See narrative under task # 133.

144. Implement cross-pollination as needed.

See narrative under task # 134.

145. Map and monitor all individuals.

See narrative under task # 135.

15. Create and/or expand scientifically managed germplasm reserves including a seed bank and specimens at mid-elevation sites.

Ex situ conservation is essential as a safety measure to preserve the existing gene pool in case of accidental stochastic extinction of individuals or populations in the wild. Germplasm banks including long-term storage of seeds, plant tissue and live individuals must be established to reduce the loss of genetic variability resulting from the death of wild plants. This germplasm can be used to establish new populations and to maintain the genetic integrity of existing ones.

Germplasm should be collected from as many plants of each species as possible to capture as much genetic variation as possible. However, cuttings and air layers must be made with care to prevent undue damage to the plants, and seed collection should be monitored carefully to detect possible negative effects to the wild populations.

Germplasm should be maintained or stored at appropriate facilities meeting stringent criteria. These criteria should include proper labeling, cleaning, handling, and storage techniques to ensure maximum long-term viability of the germplasm. As the genetic integrity of these species depends in part on appropriate germplasm storage, only facilities meeting these criteria should be selected.

16. Conduct systematic field surveys for new and existing populations.

The precise range and population size of each species needs to be established, and damage caused by Hurricane Iniki should be assessed.

161. Initiate surveys for new and existing populations of the five species.

Surveys of existing populations are needed to asses the damage caused by hurricane Iniki. Further field work on Kaua'i is likely to yield additional populations of some, if not all, of the five species. Intensive field work should be carried out to locate additional populations of these five species in intervening areas along the windward escarpments of the island. Similar habitats directly north and west of the Wahiawa Drainage, e.g., in the privately-owned Hanapepe River and Olokele River Valleys, probably harbor some, if not all of these species.

162. Include newly discovered populations in management

plans.

The habitat of any newly discovered populations should be protected and maintained as necessary and appropriate following the protocol given for the Wahiawa Drainage, Waioli Stream Valley and Makaleha Mountains.

2. Conduct basic research essential to the conservation of the five species.

Few details regarding the ecology, demographics, propagation, habitat requirements and basic life history of these five species are known and such knowledge is essential to their conservation.

21. Develop methods of controlling alien weeds, particularly those utilizing biological control.

Research to develop biological control measures for these pernicious aliens should be given high priority, as they are a serious threat to the species in this plan and are rapidly becoming serious weeds throughout Hawai'i.

22. Study life history and reproductive biology.

Basic research and field observations need to be conducted on the reproductive biology of each species, both *in situ* and *ex situ*. Each wild plant should be mapped and accurate records kept on its phenology and the effects of environmental factors on flowering and seed production.

23. Determine genetic variability and susceptibility to inbreeding suppression.

The genetic variability of each species must be established by isozyme and/or DNA analyses to develop effective strategies for enhancing existing populations and establishing new ones. The breeding system and susceptibility of each species to inbreeding depression also needs to be investigated.

24. Determine factors limiting growth and reproduction.

Ecological factors limiting growth and reproduction need to be ascertained for each species in order to ensure the success of this recovery plan.

241. Determine the mechanisms by which alien weeds impact the species, if necessary.

The mechanisms by which alien weeds impact the species should be studied if needed.

242. Determine the effects lack of pollinators may have on seed set.

The loss of native pollinators and possible resulting reduced seed production and viability should be studied, particularly for Cyanea undulata, Dubautia pauciflorula, and Hesperomannia lydgatei.

243. Determine the effects low bird densities may have on dispersal and germination.

The seeds of Cyanea undulata and Labordia lydgatei may require passage through a bird's digestive tract for optimum germination, and may also be adapted for dispersal by sticking to birds' bodies. The effects of native bird decline and any dispersal done by introduced birds should be studied.

244. Determine the effects of rats on survival and reproduction.

The impact of rats as seed predators and herbivores needs study.

25. Develop methods of controlling the factors limiting growth and reproduction.

From the results of the above studies, methods to control the factors limiting growth and reproduction of these species can be developed.

251. Develop methods for enhancing pollination and seed set.

Methods for enhancing pollination and seed set should be developed.

252. Develop methods for enhancing seed germination.

Methods for enhancing seed germination should be developed.

253. Develop methods for reducing seed predation.

Methods for reducing seed predation should be developed.

26. Determine appropriate propagation and reintroduction techniques.

For each species, appropriate propagation and reintroduction techniques need to be determined. Breeding experiments including self- and cross-pollination should be attempted to

obtain seed for propagating each species, and methods for long-term seed storage should be developed. Propagation by cuttings and air layering should also be attempted if it does not negatively impact the parent plants. For example, cuttings or air layers could likely be taken from large, healthy individuals of Dubautia pauciflorula, Hesperomannia lydgatei, and Labordia lydgatei without harming them. However, the single-stemmed species Cyanea undulata and Viola helenae cannot be propagated vegetatively using standard techniques, and tissue culture or micropropagation should be attempted. As much of the original genetic diversity as possible of each species should be preserved. Careful records must be kept regarding each plant in the wild and its progeny.

3. Increase population numbers at existing sites.

Population sizes of these five species should be increased to viable numbers in the Wahiawa Drainage, Waioli Stream Valley and Makaleha Mountains. Existing populations may be augmented by enhancement of *in situ* reproduction and by planting viable seeds, cuttings, or air layers *in situ*, either directly in the ground or in pots containing soil from nearby.

31. Determine populations to be increased.

To reach the downlisting goal of enough reproductive individuals per population to sustain numbers and genetic diversity, most existing populations will need to be augmented. The Hesperomannia lydgatei population at Wahiawa Drainage numbered 281 when last surveyed, and may not require augmentation.

32. Develop a plan to increase numbers in the Wahiawa Drainage.

Detailed augmentation plans must be developed for expanding these populations and for selecting genetic stock to be used for augmentation.

321. Select genetic stock to use in increasing numbers.

To maintain existing genetic diversity, all known reproducing individuals of each species should be propagated, if possible. The results of task # 23 should be used to select the best genetic stock for each population.

322. Identify specific areas to increase numbers.

Augmentation should take place near the parent plants and in similar suitable habitats. Specific areas must be identified as the precise anticipated locations of all transplants. Trial plantings may help to define the best areas.

323. Propagate genetically suitable plants.

The primary means of propagation should be done *in situ* by planting seeds, cuttings, or air layers in pots or directly in the ground near the parent plants. If seedlings or cuttings from propagation facilities are to be outplanted, strict measures must be taken to assure that insects, diseases or pathogens will not be introduced into wild populations. Propagated individuals can then be transplanted to augment existing and newly established populations.

3231. Establish a mid-elevation propagation facility.

Previous experience has demonstrated that these species fail to thrive at existing low-elevation gardens such as the National Tropical Botanical Garden and Waimea Arboretum, probably because of the high temperatures and low relative humidity at these garden sites. It is therefore imperative that a secure mid-elevation propagation facility be established on Kaua'i at a site such as Koke'e State Park.

3232. Propagate plants.

Appropriate numbers of each species and each genetic stock should be propagated. This should include enough individuals for outplanting required for augmenting existing populations and for establishing new populations (Task # 4).

324. Transplant nursery-grown plants.

The introduction of nursery-propagated plants carries the risk of introducing insects, diseases and soil pathogens. Consequently, this method should be done with utmost care. That is, only material propagated by tissue culture or micropropagation, or seedlings grown in sterile media should be used. Seedlings should be transplanted if crowded, and plants that have failed to survive transplantation should be replaced with genetically similar material.

325. Control alien weed species around new plants.

Alien plants should be controlled as in task # 132.

326. Control seed predation within expanded populations if necessary.

If seed predation is a problem in the expanded populations, appropriate control measures should be implemented.

33. Develop a plan to increase numbers in the State owned Waioli Stream and Makaleha Mountains areas.

See narrative under task # 32.

331. Select genetic stock to use in increasing numbers.

See narrative under task # 321.

332. Identify specific areas to increase numbers.

See narrative under task # 322.

333. Propagate genetically suitable plants.

See narrative under task # 323.

334. Transplant nursery-grown plants.

See narrative under task # 324.

335. Control alien weed species around new plants.

See narrative under task # 325.

336. Control seed predation within expanded populations.

See narrative under task # 326.

4. Establish new populations.

Plans must be developed for establishing new wild populations, including the selection of genetic stock. Ideally, additional populations of each species should be sought on Kaua'i. If these cannot be located or do not exist, and new populations must be established, then a protocol must be formulated for establishing new populations.

41. Select a suitable introduction site(s).

One or more ecologically similar sites within the historical range of the species should be sought and identified.

42. Secure the new site(s).

A cooperative agreement, lease, fee purchase, conservation easement or other arrangement should be made with the landowner to secure the new site(s).

43. Construct and maintain fencing for new site(s) if necessary.

If necessary, fencing should be installed and maintained to contain the populations and exclude feral animals.

44. Control alien weeds within new site(s).

After selection, the site(s) should be prepared by removing alien weeds. Follow-up monitoring and weed control should be done to prevent recurrent growth and to eliminate the weed seed bank.

45. Select genetic stock to use in establishing new populations.

Genetic stock should be obtained from existing plants at newly discovered populations. Newly discovered plants should be backed-up at a propagation facility and also used to enhance that population. When establishing a new population, the results of task # 23 should be used to choose the most appropriate genetic stock for each species.

46. Transplant propagated individuals.

See narrative under task # 324.

5. Verify the scientific validity of the recovery objectives.

It is important to determine and verify the scientific validity of the recovery objective proposed herein.

51. Determine the number of populations needed to ensure survival of the species from catastrophic events over the next 200 years.

It will be important to know if the current objectives call for enough populations for these species to survive long term impacts such as hurricanes, volcanic eruptions and inbreeding suppression.

52. Determine the number of individuals needed to ensure the long-term survival of each population.

It will be important to know how many individuals will be enough to sustain populations and to guard against inbreeding suppression.

53. Revise recovery objectives as necessary.

The recovery objectives should be revised as often as warranted by new information.

54. Determine if hypothesized human-induced changes in climate will affect populations.

Hypothesized human-induced changes in global climate may also impact on local climates and thus plant distributions. It would be prudent to hypothesize how these global climate changes might affect the long-term survivability of existing populations.

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III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the Wahiawa 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 populations sizes and numbers on Kaua'i. Monetary needs for all parties involved are identified to reach this point.

Recovery Plan Implementation Schedule for Wahiawa Cluster Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
Secure current habitat:											
1	11	Negotiate a cooperative agreement with McBryde Sugar Co.	2	* ES DLNR MSC	0.5 0.5 0.5		0.25 0.25 0.25	0.25 0.25 0.25			
1	12	Negotiate an agreement with DLNR for management of Waioli and Makaleha habitat	2	* ES DLNR	0.5 0.5		0.25 0.25	0.25 0.25			
Manage Wahiawa populations:											
1	1311	Construct and maintain fencing	C	* DLNR ES	61 61		30 30	25 25	3 3	3 3	
1	1312	Establish a feral ungulate control program	C	* DLNR ES	22 22		10 10	10 10	1 1	1 1	
1	1313	Control insect seed predators	C	* DLNR ES	2 2		0.5 0.5	0.5 0.5	0.5 0.5	0.5 0.5	
1	1314	Control rats as necessary	C	* DLNR ES	8 8		2 2	2 2	2 2	2 2	
1	1321	Schedule weedings to control alien plants	C	* DLNR ES	8 8		2 2	2 2	2 2	2 2	
1	1322	Monitor alien plants	C	* DLNR ES	2 2		0.5 0.5	0.5 0.5	0.5 0.5	0.5 0.5	
1	1323	Implement biological control of alien plants	C	* DLNR ES	TBD TBD			TBD TBD			
1	133	Consider slope stabilization	2	* DLNR ES	2 2		1 1	1 1			
1	134	Implement cross-pollination as needed	C	* DLNR ES	4 4		1 1	1 1	1 1	1 1	
1	135	Map and monitor all individuals	C	* DLNR ES	5 5		2 2	1 1	1 1	1 1	
Manage Waioli and Makaleha populations:											
1	1411	Construct and maintain fencing	C	* DLNR ES	61 61		30 30	25 25	3 3	3 3	

Recovery Plan Implementation Schedule for Wahiawa Cluster Plants

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
1	1412	Establish a feral ungulate control program	C	* DLNR ES	22 22		10 10	10 10	1 1	1 1	
1	1413	Control insect seed predators	C	* DLNR ES	2 2		0.5 0.5	0.5 0.5	0.5 0.5	0.5 0.5	
1	1414	Control rats as necessary	C	* DLNR ES	8 8		2 2	2 2	2 2	2 2	
1	1421	Schedule weedings to control alien plants	C	* DLNR ES	16 16		4 4	4 4	4 4	4 4	
1	1422	Monitor alien plants	C	* DLNR ES	2 2		0.5 0.5	0.5 0.5	0.5 0.5	0.5 0.5	
1	1423	Implement biological control of alien plants	C	* DLNR ES	TBD TBD			TBD TBD			
1	143	Consider slope stabilization	2	* DLNR ES	2 2		1 1	1 1			
1	144	Implement cross-pollination as needed	C	* DLNR ES	4 4		1 1	1 1	1 1	1 1	
1	145	Map and monitor all individuals	C	* DLNR ES	5 5		2 2	1 1	1 1	1 1	
1	15	Create/expand germplasm reserves	2	* NTBG DLNR ES	20 20 20		5 5 5	5 5 5	5 5 5	5 5 5	
1	161	Survey for new and existing populations	2	* DLNR ES	40 40		20 20	20 20			
1	162	Include newly discovered populations in management plans	1	* DLNR ES	TBD TBD			TBD TBD			
		NEED 1 (Secure and manage current sites)			614.5	0	256.25	232.25	63	63	
2	21	Develop methods for control of alien weeds	10	* DLNR FWS-RES ES	50 140 10	10 28 2	10 28 2	10 28 2	10 28 2	10 28 2	Ongoing
2	22	Study life history and reproductive biology	10	FWS-RES * DLNR	224 32		56 8	56 8	56 8	56 8	

Recovery Plan Implementation Schedule for Wahiawa Cluster Plants

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURA-TION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
2	23	Study genetic variation and inbreeding supression	5	* FWS-RES	224		56	56	56	56	
				DLNR	16		4	4	4	4	
2	241	Determine impacts of alien weeds, if needed	5	FWS-RES	TBD		TBD				
				* DLNR	TBD		TBD				
2	242	Determine effects of lack of native pollinators	5	FWS-RES	112		28	28	28	28	
				* DLNR	16		4	4	4	4	
2	243	Determine effects of low bird density on dispersal and germination	5	FWS-RES	112		28	28	28	28	
				* DLNR	16		4	4	4	4	
2	244	Determine the effects of rats on survival & reproduction	5	FWS-RES	112		28	28	28	28	
				* DLNR	16		4	4	4	4	
2	251	Develop methods to enhance pollination and seed set	5	FWS-RES	112		28	28	28	28	
				* DLNR	16		4	4	4	4	
2	252	Develop methods to enhance germination	5	FWS-RES	112		28	28	28	28	
				* DLNR	16		4	4	4	4	
2	253	Develop methods to reduce seed predation	5	FWS-RES	112		28	28	28	28	
				* DLNR	16		4	4	4	4	
2	26	Determine propagation and reintroduction techniques	5	FWS-RES	32		8	8	8	8	
				* NTBG	480		120	120	120	120	
				DLNR	32		8	8	8	8	
NEED 2 (Conduct essential research)					2008	40	492	492	492	492	
2	31	Determine populations to be increased	1	* DLNR	1		1				
				ES	1		1				
Increase Wahiawa populations:											
2	321	Select genetic stock for increasing populations	1	* DLNR	5				5		
				ES	2.5				2.5		
2	322	Identify areas to increase numbers	1	* DLNR	2			2			
				ES	1			1			
2	3231	Establish a mid-elevation propagation facility	3	* ES	30		10	10	10		
				DLNR	6		2	2	2		
				NTBG	6		2	2	2		

Recovery Plan Implementation Schedule for Wahiawa Cluster Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
2	3232	Propagate apropriate genetic stock	5	* DLNR NTBG ES	100 100 50				50 50 25	50 50 25	
2	324	Transplant nursery-grown plants	5	* DLNR ES	0 0						
2	325	Control alien weeds around new plants	C	* DLNR ES	3 3			1 1	1 1	1 1	
2	326	Control seed predation in expanded populations	C	* DLNR ES	3 3			1 1	1 1	1 1	
Increase numbers in Waioli and Makaleha populations:											
2	331	Select genetic stock	1	* DLNR ES	2 1			2 1			
2	332	Identify areas to increase numbers	1	* DLNR ES	2 1			2 1			
2	333	Propagate genetically suitable plants	5	* DLNR NTBG ES	36 36 12			12 12 4	12 12 4	12 12 4	
2	334	Transplant nursery-grown plants	5	* DLNR ES	0 0						
2	335	Control alien weeds around new plants	C	* DLNR ES	6 6			2 2	2 2	2 2	
2	336	Control seed predation in expanded populations	C	* DLNR ES	4.5 4.5			1.5 1.5	1.5 1.5	1.5 1.5	
NEED 3 (Augment current populations)					427.5	0	16	62	185.5	164	
2	41	Select introduction site(s)	2	* DLNR ES	2 1			1 0.5	1 0.5		
2	42	Secure new site(s)	2	* DLNR ES	0.5 0.5			0.25 0.25	0.25 0.25		
2	43	Construct and maintain fencing at new site(s) if necessary	C	* ES DLNR	40 40				20 20	20 20	
2	44	Control alien weeds in new sites	C	* DLNR ES	1 1					1 1	

Recovery Plan Implementation Schedule for Wahiawa Cluster Plants

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	TOTAL COST	COST ESTIMATES ($1,000'S) FY1993	FY 1994	FY 1995	FY 1996	FY1997	Comments
2	45	Select genetic stock for establishing new populations	1	* DLNR ES	5 2.5				5 2.5		
2	46	Transplant propagated individuals	5	* DLNR ES	0 0						
		NEED 4 (Establish new populations)			93.5	0	0	2	49.5	42	
3	51	Determine # of individuals needed for 200 year survival	3	* FWS-RES DLNR ES	0 0 0						
3	52	Determine # of individuals needed for 200 year survival	3	* FWS-RES DLNR ES	0 0 0						
3	53	Revise recovery objectives	1	* ES DLNR	0 0						
3	54	Determine if human-induced changes in climate will affect populations	0	* FWS-RES ES DLNR	0 0 0						Ongoing
		NEED 5 (Validate recovery objectives)			0	0	0	0	0	0	
		TOTAL YEARLY COST			3143.5	40	764.25	788.25	790	761	

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 or habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Key to Acronyms Used in Implementation Schedule:

ES	-	Fish and Wildlife Service, Ecological Services, Honolulu, Hawaii
DLNR	-	Hawaii State Department of Land and Natural Resources
FWS-RES	-	Fish and Wildlife Service, Research Division
MSC	-	McBryde Sugar Company, Ltd.
NTBG	-	National Tropical Botanical Garden, Kauai

Key to Other Codes Used in Implementation Schedule

C	-	Continuous task
O	-	Ongoing (already begun as of writing of plan)
0	-	Total cost is shown as zero for tasks scheduled to begin after Fiscal Year 1997

APPENDIX A - INDIVIDUALS CONTACTED DURING PLAN REVIEW

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